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EDITORIAL.

ITEMS AND NOVELTIES.

The Boilers Tested at the Exhibition of the American *Institute*, 1871.—In connection with the elaborate and very valuable report of the Committee appointed by the American Institute at its last exhibition, which appears in this number of the "Journal," a short description of the competing boilers tested by it, with engravings, is herewith given from advance sheets of the report referred to.

The Root Boiler (plate vi, figs. 1, 2,) consists essentially of 80 wrought iron tubes, each 4 inches in diameter, and 9 feet long. These tubes are set in brick work, at an angle of about 30° from the horizontal, and are connected together by the system of triangular plates and crowfeet shown in figs. 1 and 2, the joints being formed by the aid of rubber grummets.

The boiler has a steam drum, 18 inches in diameter, and 6½ feet long. The superheating is effected in the upper portion of the boiler, where the tubes are, like those forming the water space, surrounded by the heated gases. The water was maintained during the trial just above the fourth row of tubes.

The inventor claims that by the contraction of the passages, caused by the method of connecting the tubes, the steam is disengaged from the water in a comparatively dry state.

The Allen Boiler (figs. 3, 4).—This boiler possesses several novel features. There are 9 cast iron cylinders, A, A, A, etc., each 7 inches internal diameter, and 11 feet long; and into each of these cylinders 18 wrought iron tubes, B, B, each 3½ inches in dimeter, and closed at one end with plugs, are screwed. In each section of wrought iron tubes, 9 of the tubes have a length of 3 feet and 2 inches, and the remaining 9 have a length of 4 feet and 5 inches each. The sections are all connected by the cast iron cylinders to a steam drum, C, 2 feet in diameter and 8 feet long; and this drum is connected with another, D, 2½ feet in diameter and 8 feet long. (This drum has been omitted in the engraving.) From this latter drum the steam leaves the boiler by the pipe E. These drums are so arranged as to superheat the steam, being surrounded by the products of combustion; and in the bottom of each of the drums are pipes, F, G, connecting with H, the lowest point of the boiler, to allow the water carried over by the steam to drain back. The feed and the water gauge and gauge cocks are connected to the steam and water spaces by the pipes J, K, L, leading to the steam drum, C, and the cross connection, H, respectively. The wrought iron pipes are conneted to the cast iron cylinders at an angle of 20° from the vertical, the inventor claiming that as the most effective position. The inventor also claims great facility for making repairs by merely unscrewing a defective tube and substituting a good one.

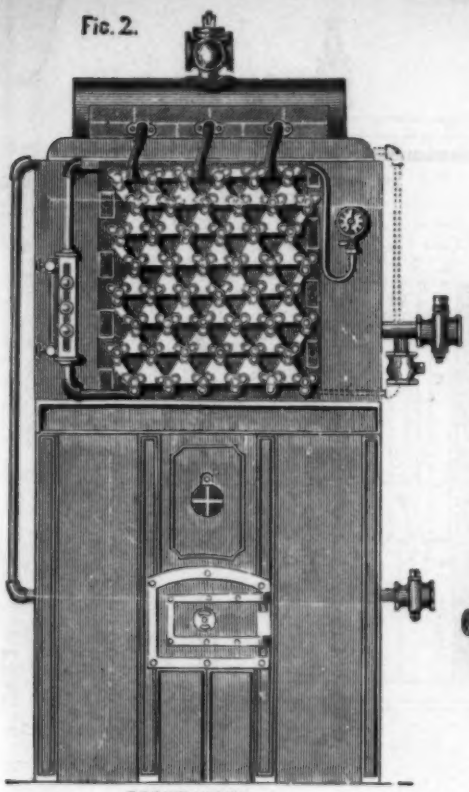
The Phleger Boiler (fig. 5), as built by Messrs. Lady & Verner, of Phleger Safety Boiler and Machine Works, Thirtieth and Chestnut streets, Philadelphia, is described as follows:

The steam-generating surface consists of a series of wrought iron lap welded boiler tubes, 2 inches in diameter, firmly expanded into wrought iron sheets ⅛ of an inch in thickness. The back flue sheet, with cap bolted on, is free to expand and contract. The tubes are arranged so as to give a free upward flow or circulation of the entire body of water through the tubes to the steam drum, from which it returns by means of a stand or side pipe outside and away from fire surface, which is claimed to give a perfect circuit to the water (as seen by direction of arrows in cut), and to keep all parts of uniform temperature free from scale and sediment, the current washing any impurities in water into mud drum, where it can be blown off at convenience. There are no joints or connections exposed to the fire.

The inventor amongst other things claims for this boiler perfect cir-

ROOT BOILER.

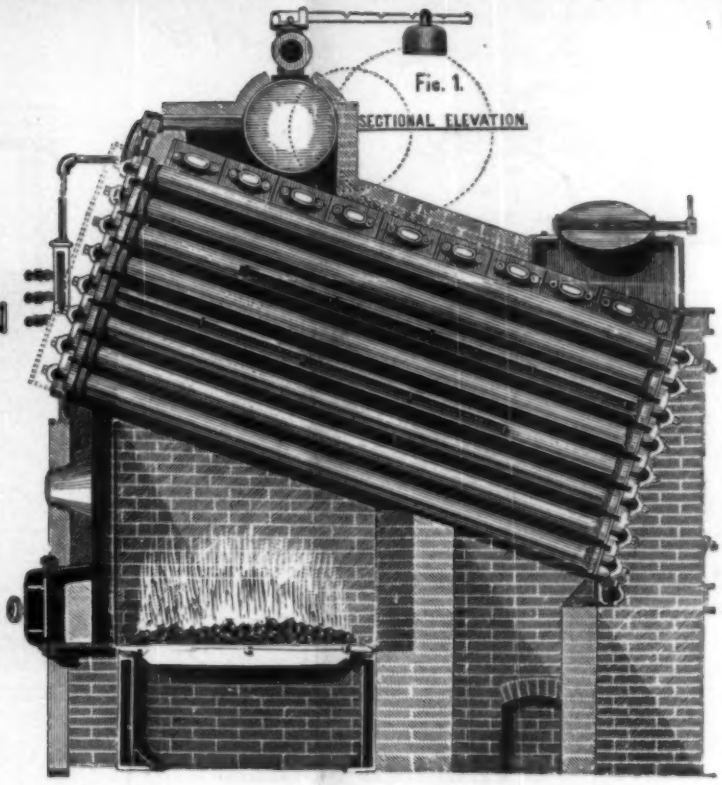
Fig. 2.



FRONT VIEW

Fig. 1.

SECTIONAL ELEVATION.



LOWE BOILER.

Fig. 7.

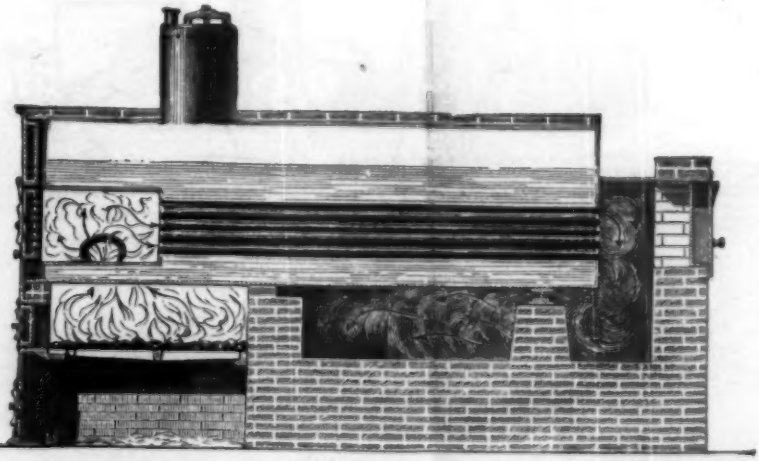


Fig. 6.

ALLEN BOILER.

75 HP

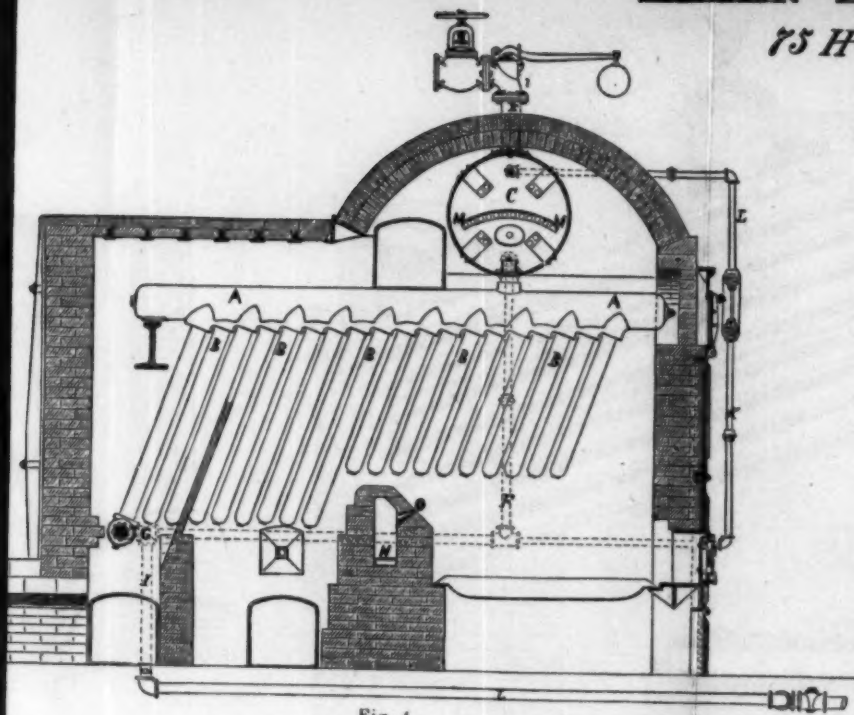


Fig. 4.

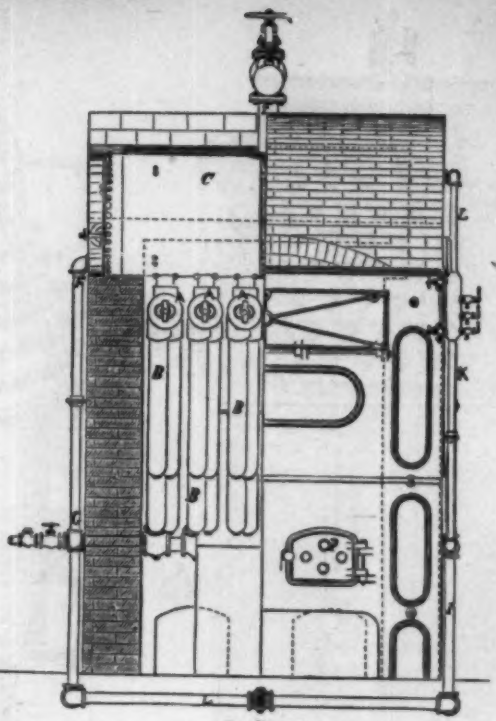


Fig. 5.

PHLEGER BOILER.

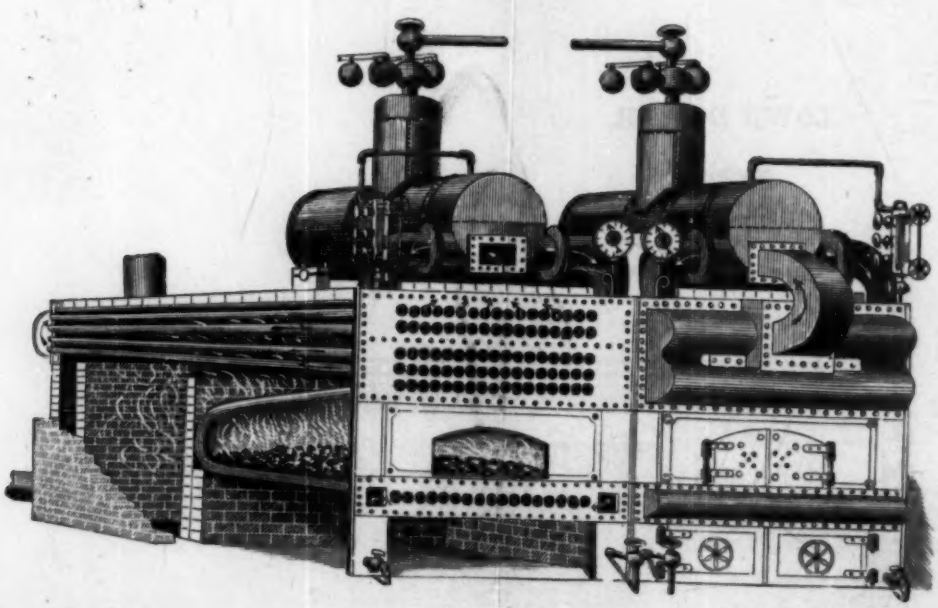


Fig. 3.

culation of the entire body of water, durability, economy of fuel, and great convenience in repairing.

The Lowe Boiler (figs. 6, 7).—This is a tubular boiler, set in brick work. The principal claim of the patentee is an improved arrangement of the flues and setting, for the purpose of securing more perfect combustion. The products of combustion pass from the furnace through openings into the combustion chamber. Air is admitted to the chamber by a register, the amount of opening being varied, until it is judged that the best effect is produced. The further course of the gases is plainly marked by the arrows, through the tubes and under the boiler, passing by a drop flue to the chimney.

By this arrangement of the combustion chamber, the inventor claims to effect a more perfect combustion of the gases of the fuel than can be produced in any other boiler of this class.

In the trial, two boilers, placed side by side, were tested. The larger boiler was 4 feet in diameter, 15 feet and 4 inches long, and contained 45 tubes, each three inches in diameter and 12 feet long. The other boiler was of the same length as the first, but only 3½ feet in diameter, and contained 36 tubes, of the same dimensions as those in the first.

The Blanchard Boiler.—Not having received the engraving of this boiler, an intelligent description is difficult. It can, however, be stated that a mechanical draft is employed. The air, instead of being forced through the ash pit, as is usual, is drawn by the action of a fan-like screw placed in the smoke pipe above the heaters, the fan being driven by a belt from the fly-wheel of the feed-pump.

By this arrangement the inventor claims that he can utilize the products of combustion in a very thorough manner, and also that he can employ a much larger ratio of heating to grate surface than is commonly possible. In the smoke pipe is placed an arrangement of tubes for superheating the steam, and above this a second series for heating feed-water.

New Lecture Experiments.—*The Action of Lenses Illustrated.*—In the "Quarterly Journal of Science" for April is an account of a very ingenious arrangement of the vertical lantern by Dr. R. M. Ferguson. In this an ordinary retort stand is used for the framework, and the mirrors, &c., are attached by the usual rings and clamps of that apparatus. The most important feature, however, is the substitution of a glass bowl or evaporating dish, full of water, for the horizontal element of the condenser.

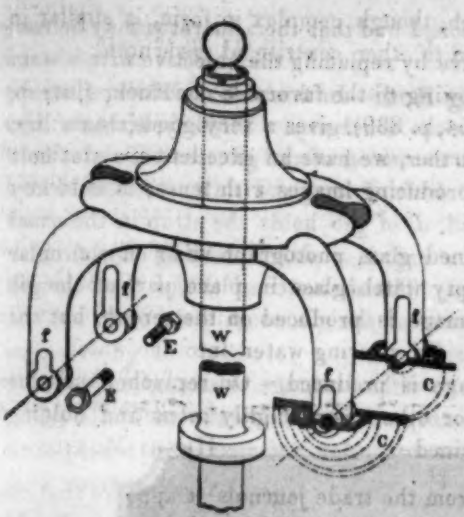
Carrying out this suggestion, I find that the apparatus may be made yet simpler and less expensive by replacing the objective with a watch glass, full of water, which, owing to the favorable conditions fully discussed in this journal (vol. 54, p. 339), gives a very good image. Carrying out this idea a step further, we have an excellent illustration of the action of refraction in producing images with lenses, and some of its conditions.

Thus we place a well-defined glass photograph as an object in the vertical lantern, and an empty watch glass in place of the objective. As a matter of course no image is produced on the screen, but only a nebulous patch of light. On pouring water into the watch glass, however, a well-defined image is produced. On replacing the water by alcohol, muriate of tin, or other more highly refracting liquid, a ens of higher power is obtained. HENRY MORTON.

Statistics of Coal.—From the trade journals it appears that the amount of coal now shipped from Pittsburgh is enormous. During one week there were shipped from that port, mainly to Cincinnati, seven millions five hundred and three thousand bushels of coal.

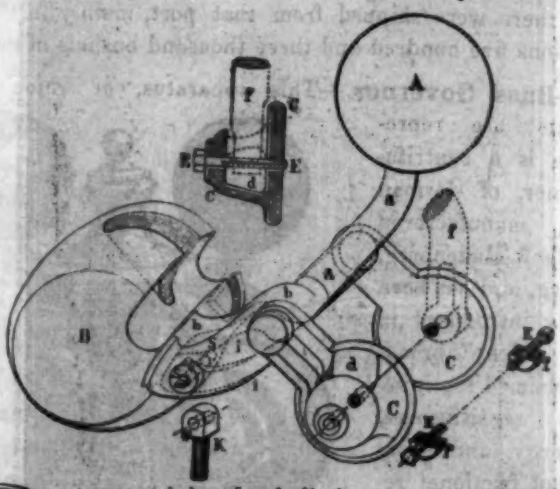
The Buss Governor.—This apparatus, of which the annexed cuts are representations, is a centrifugal governor, of German invention, manufactured by Schaeffer & Budenberg, in Hamburg, and has been extensively introduced in machine shops abroad. There is claimed for it remarkable sensitiveness, great energy, and great reduction of frictional resistance. (For the illustrations we are indebted to the kindness of the Editor of our esteemed contemporary, *Der Praktische Machinen Constructeur.*

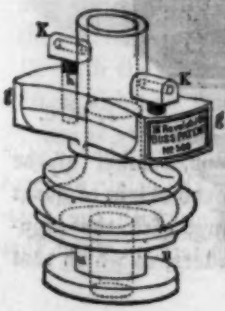
The governor consists essentially of the following



parts: A vertical shaft, a cast-iron pendulum bearer, two cast iron pendulums with four steel pins, and a cast iron box.

The attachment of the vertical axis can be arranged to drive the apparatus either from above or beneath. The cast-iron pendulum bearer is attached to the shaft W, its four crossing arms f, f, &c., carry the axles E and E, of the pendulums. Each of the pendulums consists





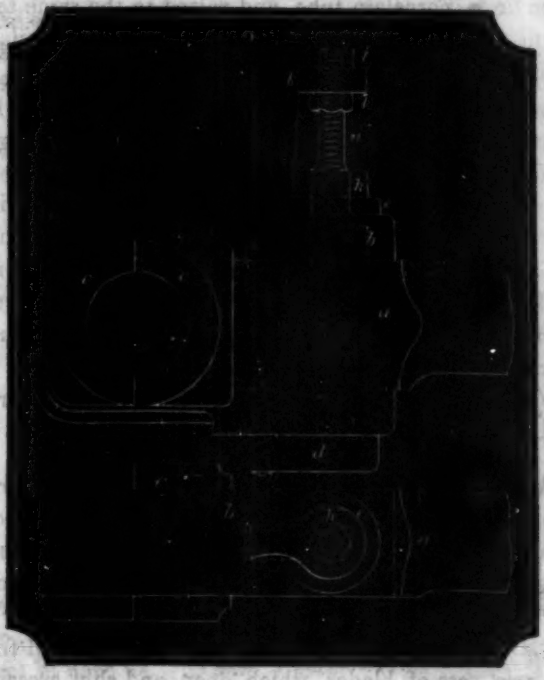
mainly of a ball A, and a barrel-shaped weight B. These are attached by arms a, a and b, b to two cases C and C. To each of these last is attached an arm f, of the pendulum bearer, and through each of the cases C and arm f, fitting into it, there is screwed a steel pin E. Two of these pins (which are at some distance from each other), form the axis of the pendulum.

The illustrations afford exterior and sectional

views of the apparatus, which, though complex in form, is similar in the principles of its operation to other centrifugal governors.

Stub-end of Connecting Rod.—In this stub the block, *a*, strap, *b*, and boxes, *c c*, are made in the usual way. The key, *k*, has a lug, through which the belt, *n*, an extension of the gib, passes, a slot hole being provided to allow for draft of key, and nuts, *i i*, to hold key securely in place. The head, *d*, of gib holds the strap in the usual way, but on the other end a nut, *h*, is placed, resting on a circular washer, *e*, notched at the key. The diameter of this part of the gib is made more than the thickness of the gib, to gain strength, but the extension, *n*, may be made less.

This plan may be resorted to with advantage to strengthen existing stubs, giving the bolt to the strap and screw adjustment and holding



to the key. J. H. C.

Crystallized or Burnt Iron.—In a previous number of the "Journal," the views of Mr. W. M. Williams upon the origin of burnt iron, or iron which has been damaged by reheating, with the arguments sustaining them, were presented to our readers, in which that

gentleman supported the opinion that the injurious effects are produced by the absorption of oxygen, which really burns the substance, partially removing, in the case of steel, the carbon and imprisoning carbonic oxide in its interior, and in case of iron, oxidizing the metal itself; in either case, breaking the continuity of the texture, and hence its tenacity, by the introduction of worthless combustion products.

M. Caron, maintains, however, that the deterioration of "burnt" iron is due, not to the absorption of gases, but simply to the action of heat modifying the molecular constitution; and this opinion he supports by the following experiments: A piece of iron, with good fibrous properties, was broken into small pieces; some were placed in the fire of an ordinary forge, and raised to a welding heat; others were placed in a porcelain tube, and raised to the same temperature in a current of hydrogen or nitrogen. Both were similarly cooled, and both presented the crystalline structure of burnt iron.

The same author supports the opinion that vibration has not the slightest effect in rendering iron brittle, or in modifying its fibrous texture, and that the explanation of frequent breakages is to be ascribed rather to bad form, or to the original inferiority in the quality of the iron. He likewise combats the idea that the frequent fracture of railway axles in cold weather, and the crystallized texture of the broken bars, is any proof that cold is the cause of the crystallization and consequent brittleness, urging that there is no evidence this was not the condition of the metal before use, and that the greater hardness of the ground, greater severity of shocks, &c., are the more rational reasons for such accidents.

New Mode of Propelling Ships.—A contemporary contains an account of an experimental trial upon a small model of a vessel, the design being to test the practicability of a new mode of propelling ships. The inventor proposes, by a novel contrivance, to make the waves acting on the hull of the ship do the work of propelling it. Beneath the keel of the vessel he fixes two oblong steel frames, each fitted with two sets of blades, which open and shut crosswise. One frame is secured to the fore part, the other to the stem of the vessel. When the vessel rises in the sea, the presence of water upon the frames, it is said, forces her forward; and when she sinks, the opening of the blades would form the opposite angle, and continue the onward motion. The opening or closing of the blades on either side,

as the vessel rolls, it is claimed will have the effect of steadying the motion of the ship. The angle of the frames may be increased or diminished according to the state of the weather. To stop, the blades in the frames are closed.

The inventor believes that the plan would furnish sufficient propelling power to ships not requiring to travel with great speed, and would supply them with a limited amount of rigging as auxiliary against accident, or whenever there is not sufficient motion at sea to raise the vessel several feet, which is rarely the case. At the trial, a miniature vessel, 7 feet in length, held its way against the tide, and even in comparatively still water travelled at considerable speed.

Wrought Iron Ties.—Certain English journals speak highly of the anticipations formed of the new railway sleeper recently brought out in England. The constructors of railroads in tropical countries, it seems, are disposed to regard them with special favor. In India, our authority tells us, unusual difficulties are experienced with the wooden sleeper—the dry rot and the white ants seldom allow them, even when protected by chemical preparation, a longer lease for usefulness than three years. The new sleeper is expected to show decided advantages. It is made up of a number of webs and plates of rolled iron, riveted together and pierced with bolt holes for the chains. On the score of cost, it is estimated that this will not exceed that of the best wooden sleepers by more than a shilling each, while ten times the wear is anticipated from them in tropical countries, and three or four times in Europe. Those in use on several Belgian railways are pronounced to be all that are claimed for them.

A Submerged Bridge.—A bill is at present pending in Congress to incorporate the New York and Brooklyn Submerged Tubular Bridge Company, the object of which is to run a tube under the East River, to connect the two cities named above. The bill will authorize the laying of a wrought iron tube 2640 feet long, 60 feet broad in the clear, and 24 feet high, at a cost of $2,500,000. The tube is designed to accommodate foot passengers, vehicles and railway cars. It is anticipated that the committee having it under consideration will report favorably upon it.

Lecture Illustrations of Diffusion, &c.—Mr. Ferd. Fischer illustrates the phenomenon of diffusion of gases in the following manner:* This apparatus, figured opposite, is a modification of the one

* Ber. d. d. chem. Gesell. v, 264.

nearly always used for the purpose, and consists essentially in surrounding the porous cylinder, A, (fig. 1), with a bell glass, E, having a doubly perforated cork, furnished with glass tubes for supplying the interior with various gases; while the long tube, B, terminates in a flask, C, nearly filled with a colored liquid, and furnished also with a doubly perforated cork, the second opening in which is occupied by a small tube terminating just above the flask.

If now carbonic acid gas is introduced into E, the colored liquid in C rises in B to a considerable height; a strong current of hydrogen through the other tube causes the fluid almost instantly to be ejected from C to a height nearly equal to that of the apparatus.

Specific Gravity.—Fig. 2 is a modification of the first, for the purpose of simply illustrating the relative specific gravity of gases; *e* is an ordinary lamp chimney set upon the edge of the funnel, while *d* is prolonged from the lower flask to a considerable distance.

By leading into *e*, a gas heavier than the atmospheric air, the liquid in *e* rises in *b*; the heavier the gas the higher the rise in *b*.

Gases lighter than the air drive the liquid up the tube *d*; the lighter the gas the higher the column rises.

Flame Reactions with Hydrogen Gas.—Mr. W. F. Barrett has published some interesting observations on the phenomena associated with a hydrogen flame, of which a brief abstract is given below.*

The gas is thoroughly purified by washing with potash and subsequently with nitrate of silver or perchloride of mercury, and is to be led through a black rubber tube to a steatite jet, and burned in a perfectly dark room free from dust. Under these circumstances, it appears that the flame possesses a faint reddish-brown tinge, while a stream of lumin-

* Nature v. 482.

osity extends upwards beyond the flame proper, to more than six times its length. When brought into contact with solid bodies, in many cases phosphorescent effects are produced. Sandpaper brought into it for a moment shows a vivid green light, remaining for some seconds after the flame is extinguished. Writing paper, marble, gypsum and granite gave similar effects. The presence of the least trace of sulphur, either in the air in the delivery tubes, or upon the objects tested, invariably cause a deep blue coloration of the flame. As a chemical reagent for detecting sulphur, the author pronounces the flame to be wonderfully sensitive. Phosphorus and its compounds give a green color to the flame, and carbonic acid at once imparts to it a pale lilac tinge.

From these observations it would seem that pure hydrogen might be made serviceable in producing phosphorescent effects, and in testing for slight traces of sulphur, phosphorus and certain gases.

A New Test for Arsenic.—Bettendorf* has simplified Hager's method of testing for this substance, and, it would seem, has rendered it peculiarly suitable for testing pharmaceutical preparations for slight impurities from this element.

The method of testing commercial sulphuric acid for traces of arsenic will give a fair illustration of the author's process.

A small quantity of protochloride of tin, in a shallow dish, is covered with pure hydrochloric acid (1·12 sp. gr.) until it is dissolved. To this is added, drop by drop, the sulphuric acid to be tested, the vessel being agitated at each addition. This addition will cause considerable heating, and if no arsenic is present the liquid will remain clear. If arsenic is present in the smallest quantities the liquid will be colored first yellow, then brown, and finally a dark greyish-brown, becoming at the same time turbid.

The process, while far more readily carried out than Marsh's, is declared to be nearly equal to it in delicacy.

A New Photographic Process.—A printing process, by which a photographic image can be developed upon paper, sensitised with various metallic salts without the agency of light, has lately been announced to the French Academy by Prof. Merget of Lyons. The observations upon which this process, which bears a very remote resemblance to the old daguerreotype, is founded, are stated to be that

* Dingler's Jour., ccii, 385.

mercury possesses the property of volatilizing continuously at all temperatures, that these vapors may be condensed upon numerous substances (such as carbon, platinum, &c.,) without chemically affecting them,—while upon the solutions of salts of the precious metals these vapors have a rapid reducing action. This reducing action being purely chemical, can, therefore, take place in the dark, and the printing process is therefore rendered independent of the light.

The following is given as the *modus operandi:*

An ordinary glass negative, protected from the chemical action of the mercury by a coating of platinum or carbon particles (how?) is exposed to the action of the vapors. The vapor condenses more or less densely upon the image, and the plate is then brought into contact with the sensitised paper; prepared, as stated above, by dipping into a bath of any of the soluble salts of the precious metals. The mercural particles covering the image at once reduce the salt upon the paper, the consequence being the production of a metallic image with every gradation of tint upon the paper. When the nitrate of silver is used, the print is said to be identical with that obtained with the ordinary printing process, and is treated in a similar manner to render it permanent and heighten its tone. In this way, it is said, prints may be secured in platinum or palladium, which need simply to be washed with water to be far more durable than the paper upon which they are attached.

This plan, if the details are as simple as described, may prove to be of much practical interest, perhaps even in the reproduction of photographic images by mechanical means, which is now attracting so much attention.

The Oxygen Light.—The plan of Tessié du Motay, which has been for some time past in operation upon some of the principal boulevards of Paris, has been found unsatisfactory in several particulars, and we are informed that the lights have been removed. In addition to the use of burning gas with oxygen, it may be stated, this process requires the introduction of a super-carburetting apparatus. It would seem that practical difficulties other than the cheap preparation of oxygen gas, must be overcome before an oxygen light can be made successful.

The Temperature at the Sun's Surface.—A number of eminent scientists are at present engaged in the solution of this interesting problem. The results thus far announced are extremely unsatis-

factory; some of them differing very widely. As an instance of this difference in opinion, it may be said that the famous astronomer and spectroscopist, Pater Secchi, maintains this temperature to be about ten million degrees Centigrade.

At a recent séance of the French Academy, in defending his estimate against the much lower figures of Ericsson, Zöllner and Faye, St. Claire Deville asserted that he was engaged in investigating the subject, and that his results fixed the temperature at about three or four times the melting temperature of platinum, about 6000 to 8000 degrees (C.) Mr. Vaulle also announced an ingenious theory upon the same subject, fixing the debated figure at 10,000 degrees (C.) Finally M. Fizeau stated that, having compared the solar light with that of the carbon points of the electric light, he had been able to estimate that the former was about three times as intense as the latter, and hence, assuming the relative calorific intensity to be in proportion to the luminous intensity, he had arrived at the figure of 8000 degrees (C.) as the correct one.

A New Use for the Aniline Colors.—Mr. F. Springmühl recommends the use of alcoholic solutions of various gums (shellac, sandarach, &c.), to which various aniline colors have been added, in coloring all kinds of paper, leather, linen, &c.*

The gum solution, which should be thin, penetrates entirely through the paper and gives to it an even tone. The operation is simply to place the coloring liquid in a shallow dish, and to draw the substance to be colored through it, which is subsequently hung up to dry; when dry another color can readily be produced upon one of the sides. Sandarach is said to produce matt; shellac and most other gums, a lustrous color. By adding to the lac solutions a small quantity of some etherial oil, the substance may at the same time be perfumed. By judiciously mixing several of the lacs, any desirable tint can be produced.

A Pressure Guage for Guns.—The principle suggested by Tresca's experiments on the flow of solids has, we are informed, been applied in practice for determining the pressure produced in the bore of large guns.† A cylindrical hole, bored into the gun, is filled by a block of lead, supported behind by a steel block, through which is a

* Zeitschr. f. Färberei, 1871, No. 41.

† Eng. and Min. Journ., xiii, 283.

small cylindrical hole. When pressure acts on the lead, a portion of it is forced into the hole in the steel block. By estimating the volume of the lead found in the cavity after a discharge, a means of measuring the pressure exerted within the gun is given.

Separation of Potassa and Soda.—One of the nicest operations in the analytical laboratory, demanding at once patience and skill, consists in the separation of these substances. The reagent usually employed in this separation is the chloride of platinum, and its employment is, in many respects, unsatisfactory.

In this connection M. Th. Schlösing has presented to the French Academy a paper, in which he makes a most favorable presentation of the method long ago proposed by M. Chevreul (but which, if it has ever been used, has been altogether abandoned), founded upon the insolubility of the perchlorate of potassa in alcohol. It appears that the potash salt is the only one with this acid which gives such an insoluble precipitate, and a ready method of separation is thus given; so easy, indeed, from all appearances, that the difficulty of preparing the reagent has probably been the cause of its abandonment for so long a time. M. Schlösing, after stating the results of some analyses conducted upon this plan, and which are extremely accurate, gives a method of cheaply preparing the perchlorate of ammonia, the reagent which he prefers for the purpose. One method which he recommends, is to form the chlorate of soda by leading chlorine into a solution of common salt. From the dry salts obtained by evaporation to dryness, the chlorate alone deposited by saturating boiling water with them; and cooling, the chloride remains in solution. The perchlorate is formed from the chlorate so obtained by heating; the mixture of salts obtained being separated by dissolving in very little water, when only perchlorate goes into solution. To this is added boiling water and a saturated solution of chloride of ammonium, and upon cooling, the desired salt, perchlorate of ammonia is obtained in large crystals.

Noncombustibe Coatings for inflammible substances, like wearing apparel, &c., have been frequently recommended, under various circumstances, to prevent or at least to greatly mitigate the dreadful accidents which are of such common occurrence.*

With this object, M. A. Pastera, while approving of the use of the tungstate of soda, recommends the substitution for it of a cheaper

* Chem. News, xxv, 202.

mixture, which he asserts to be equally efficient, viz., a mixture of 4 parts of borax and 8 parts of sulphate of magnesia. These substances are to be mixed together just before being needed, dissolved in from 20—30 parts boiling water. The goods are then to be immersed, wrung out and dried.

Obituary.*—Samuel F. B. Morse.—"Prof. Morse died at his residence, in New York City, on the 4th of April, at the advanced age of 81 years. Few Americans have attained so world-wide a renown as Mr. Morse, growing chiefly out of his success in devising and introducing the system of electric telegraphy which bears his name.

"The earlier years of his life, after graduating at Yale College, in 1810, were devoted to the study of the fine arts, which he pursued for some time in London, under Benjamin West, the painter. In sculpture he was so successful that his 'Dying Hercules' was crowned by the gold medal of the Adelphi Society of Arts, of London.

"The germs of his immortal invention, which were undoubtedly long slumbering in his mind, appear to have been stimulated by a discussion which took place on board the packet ship 'Sully,' in the autumn of 1832, while on his way to America.

"Soon after his arrival in New York he occupied himself in maturing his plans by an attempt to construct an apparatus. In 1835 he completed his first rude single receiving instrument, which he produced in duplicate in 1837. In the January number of 'Silliman's Journal' for 1838 will be found the first notice of the Morse system of telegraphic notation, with a specimen of the record then used.

"After several years vainly spent in endeavoring to secure assistance from his own government, and recognition of his rights abroad, he was gratified in receiving, on March 4th, 1843, an appropriation of $30,000 from Congress, to aid in building a telegraphic line between Washington and Baltimore, which, after many difficulties, he accomplished in 1844.

"From this first successful attempt, the system of Morse has spread with great rapidity, and is now in use in almost every civilized country. Honors were showered upon the inventor by most of the leading governments of Europe, in honor of his eminent services.

"Prof. Morse was distinguished by great amenity of manners, and

* From a notice by Prof. B. Silliman, in the Amer. Jour. of Sci., iii, III, 399.

kindness of heart, which endeared him to a large circle of friends. He was emphatically an *inventor*, using the discoveries of science to perfect his inventions. Gifted with a far-reaching mind, and indomitable energy, his faculties were employed in conferring a great blessing upon the hmuan race."

Steam Boiler Explosions.—We have been favored with a copy of a letter of Judge J. P. Bradley, of the Supreme Court of the U. S., to the Secretary of the Treasury, strongly recommending better legislation in this matter, and urging a thorough system of experiments upon boilers actually in service, to be authorized by Congress, and to be supported by a liberal appropriation of money—the object being to determine the faults in ordinary construction of boilers, to devise means of preventing dangerous pressure, and to acquire certainty concerning as to the true causes of explosions, so that the penal laws on the subject may be enforced.

The following is a draft of the act, which it is hoped will receive the favorable attention of the Secretary and of Congress:

AN ACT TO AUTHORIZE INQUIRIES INTO THE CAUSES OF STEAM-BOILER EXPLOSIONS.

Be it enacted, &c.

Section I. That the President of the United States be, and he is hereby, authorized to cause such experiments to be made and such information to be collected as, in his opinion, may be useful and important to guard against the bursting of steam-boilers; and that he be required to communicate the same to Congress; and that the sum of one hundred thousand dollars be appropriated for the purpose of this act.

OPTICAL SECTION.

(Extracts from proceedings of the stated meeting, held April 27th, 1872.)

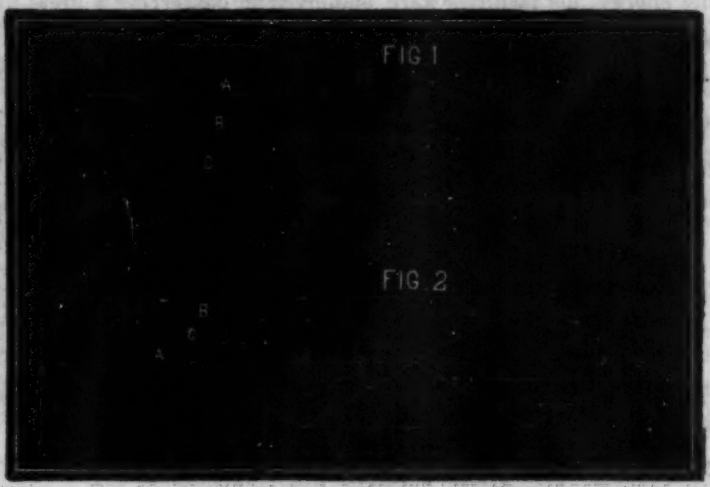
A New Erecting Prism.—By Joseph Zentmayer.—Mr. Joseph Zentmayer exhibited and described a single prism, which erects the image completely, and in such a way that the incident and emerging rays are parallel, which, as far as we know, was never accomplished before.

In connection with the microscope, as it was shown, it interfered very little with the definition, and, although the light is twice refracted and reflected, the loss of light is much less than one would expect.

With the microscope, the prism is placed right above the objective, and the instrument may be used in any inclined position.

A pair of such prisms might be used also for an erecting binocular microscope, of which the two bodies have the same inclination to the stage.

Fig. 1 shows the front and profile of the prism. The projection of the front is a square, that of the profile an isosceles triangle. The



angles at the base of the triangle are 27°19 for crown glass of a refracting index of 1·53, in order to obtain the greatest aperture combined with the smallest prism.

Fig. 2 is a view from above. The rays A, B and C of figs. 1 and 2 are the identical ones, their dotted parts are the projections of the rays inside of the glass, and their course may be readily followed in the profile, fig. 1, where the upper ray, A, emerges as the lower one, and the lower ray, C, as the upper one.

As the ray A enters in the perpendicular line above the lower edge, it will not be reflected out of its plane, while the rays B and C, entering the left side of the prism, reach the inclined faces, from which they are reflected to the opposite lower one, and are changed in their course to the right, from here again reflected, to emerge at the corresponding opposite point.

Fig. 3 is a perspective representation of the prism.

Civil and Mechanical Engineering.

REPORT OF THE COMMITTEE OF JUDGES UPON THE TRIAL OF STEAM BOILERS.—AM. INSTITUTE, 1871.

The report of the Committee of Judges of Department V, Group I, upon the steam boilers placed in competition at the Fair of the American Institute of 1871 has been made public.

The boilers tested were five in number, the Root, the Allen, the Phleger, the Lowe and the Blanchard.

We make room for extended extracts from the report, as we believe this to have been the first critically exact test of the steaming power and the economical performance ever made upon a large scale, and it is therefore of exceptional value to all steam users and boiler manufacturers, as the only available source of accurate information in regard to the types of boiler tested and, as what the Committee designed to make it, a reliable *standard* of comparison.

The Committee, after considering the relative standing of the boilers as regards safety and durability, and expressing a belief in the ultimate success of that class of boilers called "sectional," proceed as follows to describe their method of determining the value of the boilers under consideration in *economy of fuel and capacity for making steam*:—Ed.

On these two points your Committee felt it their duty to make a careful report, based upon a thoughtfully devised and critically accurate series of experiments.

The usual test of the economy of a boiler and of its capacity for making steam consists simply in determining the quantity of water passing through it and the amount of fuel consumed in the same time, taking the weight of water used per pound of coal as a measure of the economy, and the total amount of water recorded in a given time as a measure of the steaming capacity.

But steam boilers usually—and invariably when unprovided with superheating apparatus—furnish "wet steam," and the weight of water passing off unevaporated is sometimes greater than the real weight of steam made. In order to make a reliable and valuable report upon these points, it becomes necessary to determine what is

the *real* evaporation of each boiler and what weight of water passes over unevaporated.

Another extremely important fact, and one which should alone induce the Committee to propose and the Institute to permit them to adopt an exact method of determining the true evaporative efficiency of the steam boilers presented for their judgment, is that ignorant or dishonest venders of peculiar forms of boilers have frequently deceived the public and have imposed upon purchasers by apparently well-substantiated statements that their boilers have, by actual test, evaporated fourteen, fifteen, or even in some cases twenty pounds of water per pound of fuel consumed—the purchaser being unaware of the fact, so well known to scientific men and to engineers, that were it possible to obtain one pound of coal absolutely free from all impurities and composed of pure carbon, it would, if burned where no loss of heat could take place, and with the feed water at a temperature of 212 degrees Fahrenheit, evaporate but about fifteen pounds of water, and that under the usual circumstances of comparatively cold feed water and high pressure of steam, and with waste of heat by the chimney and in every direction by radiation, *very much less than fifteen pounds* must be evaporated by the very best boiler that man can build.

In order, therefore, to assist honest and skillful builders in preventing such injury of their business by those who would either knowingly or ignorantly take advantage of the lack of information possessed by the public, the Committee considered it a duty and a privilege to furnish, if possible, a weapon that might be made effective in protecting the public as well as manufacturers against such ingnorance or dishonesty. This they proposed to do by determining accurately the performance of these five boilers, which they considered to include some that rate among the best boilers made, *and thus to furnish a standard* that should at all times be valuable for purposes of comparison.

The method adopted by the Committee of Judges is an extremely simple one in principle, and has often been before proposed by engineers. Its earliest conception, probably, dates many years back. The expense attending the building of the necessary apparatus and the preparations for and the prosecution of such an exact investigation, has prevented the earlier adoption of the plan, notwithstanding the fact that its importance has long been recognized. The intelligent liberality of the Board of Managers, who promptly acquiesced in the

proposal of the Committee, and directed the committee of the board, to whom was assigned Department V, to assist in the prosecution of the work, has enabled the American Institute to practically inaugurate this method of testing steam boilers. The apparatus required in conducting the proposed tests was prepared by direction of the chairman of the committee, under the immediate supervision of Mr. J. W. Blake, the Superintendent of Machinery. To the competing manufacturers, as well as to the Superintendent, the Committee are indebted for valuable suggestions.

A large wooden tank was prepared, in which was built a surface condenser having an area of about eleven hundred (1,100) square feet of cooling surface. This latter was made by connecting up the requisite number of tubes, obtained from the Root Steam Engine Company, the peculiar method of connection adopted in the Root boiler affording excellent facilities for so doing. The Committee are greatly indebted to Mr. J. B. Root for assistance kindly tendered in this matter. Water from the hydrants was led through Worthington meters into the lower part of the tank, and, rising among the tubes of the condenser, overflowed at the top.

The steam from the boiler on trial entered the tubes at the top of the condenser, and the water of condensation flowed out at the lowest point. The currents of steam and of condensing water thus moved in opposite directions, and the steam was condensed completely with the least possible quantity of condensing water.

Thermometers were carefully made for the occasion by G. Tagliabue, and were placed as follows: One having a scale ranging from 30 degrees to 101 degrees Fahrenheit was placed at the inlet of the injection water, and its reading indicated the temperature of both feed and injection; one ranging from 100 degrees to 175 degrees Fahrenheit was placed at the mouth of the overflow pipe, and exhibited the temperature of the condensing water when discharged from the tank; one thermometer with a range of from 45 degrees to 175 degrees Fahrenheit was so placed as to indicate the temperature of the water of condensation when leaving the condenser.

Another thermometer was placed in the steam space of the boiler,

The pressure of the steam was indicated by two recording gauges, furnished by their respective patentees, M. B. Edson, and D. P. Davis, and both gave satisfactory evidence of efficiency. The indications of the former were so accurate that it was made the standard during the trial, and the latter, also remarkably accurate, by its record

of time as well as pressure, was a most valuable check upon the record of the log as obtained by observations at regular intervals.

The quantity of water passing through each boiler was determined by weighing it, 300 pounds at a time, on carefully adjusted scales.

The Superintendent of Machinery and his assistant, Messrs. J. W. Blake and J. B. Fitch, who, representing the Committee, had immediate charge of the trials, were aided, except in the test of the Blanchard boiler, by students Henderson, Hewitt, Poinier, and Post, of the *Stevens Institute of Technology*, who, under the instructions of the Chairman of the Committee, kept the log with commendable exactness, and rendered very valuable assistance.

The coal used during the whole series of trials was from the Buck Mountain Coal Company, Philadelphia, Nathan Hilles, President. It was found to be of excellent quality, and the results of the test are, therefore, more valuable as a *standard representing the efficiency of good apparatus with good fuel.* The analysis of this coal, as determined by Professor Walter R. Johnson, is given as follows:

Water, ...	0·390
Gaseous matter, including some agate, volatile at bright red heat, ...	5·515
Carbon, ...	91·016
Earthy matter and oxyd, . . .	3·079
	100·000

It would be interesting to learn the constituents of the "gaseous matter given at 5·15 *per centum*, but this the Committee were unable to ascertain. If there were, however, any combustible gases, it is exceedingly unlikely that they existed in sufficient amount to appreciably raise the evaporative efficiency of the coal, as the steam generating powers of the anthracites seem to be precisely proportional to the amounts of carbon they respectively contain. This fact was well proven by Professor Johnson, in the course of his very extended and valuable researches upon the constitution and value of American coals. (See Report on American Coals, p. 586.) The total heating value of this coal, therefore, provided all waste could be prevented, is readily calculated, and would be 13,197·32, "*British thermal units;*" *i. e.*, one pound of this coal, burned without waste, should be capable of raising the temperature of 13,197·32 pounds of water one degree Fahrenheit. This would be equivalent to evaporating 13·65 pounds of water at the temperature of 212 degrees Fahrenheit, and under atmospheric pressure. In comparing this result with the actual per-

formance on the test, it should be remembered that a large amount of coal always falls through the grate unburned, and thus greatly reduces the practical efficiency of all coals. The amount of this loss can only be approximately estimated, and the Committee judge it to have averaged at least fifteen *per cent.* during these trials.

The evaporative power of pure carbon, which has usually been found to be capable of developing 14,500 British thermal units, is fifteen pounds of water per pound of carbon, the water being evaporated under the pressure of the atmosphere at a temperature of 212 degrees Fahrenheit. All of the results obtained by the Committee are reduced to similar standard measures of thermal units developed per pound of *combustible*, and to the equivalent evaporation from 212 degrees Fahrenheit. It is by the comparison of these reduced observations, that the relative economic efficiencies of the competing steam boilers are to be determined.

The preparations for the trial having been completed, the following letters of instruction were written, and forwarded to the Superintendent of Machinery, by whom their contents were communicated to the exhibitors, and the agreement of each to the proposed terms was a condition precedent to admission for competition:

FAIR OF THE AMERICAN INSTITUTE,
NEW YORK, *October* 31, 1871.

To the Superintendent of Machinery:

SIR,—The Committee of Judges of Department V, Group I, having determined to make a thorough test of the economic values, and of the steaming capacities of the steam boilers entered for competition, you are hereby authorized and instructed to make the necessary preparations for such a test.

The steam from each boiler, when under test, will be conducted into a surface condenser of a capacity of at least eight hundred (800) square feet of condensing surface; the *water of condensation* will be collected in a tank placed beneath the condenser, and there measured; the *feed* water will be measured by a meter, and the *condensing water* will be measured in the same manner, the meters being previously tested.

The pressure of steam will be maintained constant (at seventy-five [75] pounds), by means of a safety valve placed between the boiler and the condenser, and the Committee desire that the safety valves entered by Messrs. Bulkley and Lynde be used, if possible, for this purpose, and that they thus be tested.

Each exhibitor will see that his boiler is ready for the test, his steam pipe well covered, and valves in good order. He will, before his boiler is connected for test, hand to the Committee, through the Superintendent of Machinery, a statement of the amount of heating and of grate surface in his boiler, and a further statement, that he has read this letter of instructions, taken a copy, and that he is ready to go on with the test as herein proposed.

Any exceptions taken to the proposed test, or any detail thereof, must be forwarded to the Committee, in writing, previous to entering upon the test. Any exceptions taken to the action of one exhibitor by another, or to the decision of the Judges during the trial, will be presented promptly in writing.

It is to be understood that the proposed test is made for the purpose of enabling the Committee of Judges to make up their report to the Managers, as required by regulation, with intelligence and confidence.

In conducting the test, you and your assistant are authorized to superintend and to keep the log, with the aid of such other assistants as the Committee may appoint.

The trials will be of twelve hours each, and the boilers will be tested successively in an order that will be determined by lot.

Fires will be started at nine (9) o'clock in the morning with *dry wood*, of which you will see a good supply on hand; and at the moment when steam issues freely from the safety-valve of the boiler, the test will be considered as commenced, and the fuel will be taken from the coal pile. No more wood will be used.

The coal will be weighed in buckets, carefully counterweighted on the scale, and always filled to the same weight precisely. The scales are to be tested and officially sealed before the trial.

The ashes will be weighed *dry* in a similar manner.

The dampers will be fixed wide open, unless it should become evident that the boiler "primes" or "foams" seriously in consequence.

Each half hour there will be noted in the log the time, height of barometer, steam pressure (from the same gauge in all tests), weight of coal used, weight of ashes removed, temperature of external atmosphere, of the feed water, water of condensation, steam in boiler, steam pipe, condensing water before and after leaving condenser tank, gases in flues, four feet, as nearly as is possible, from nearest heating surface, the volume of water of condensation, and the reading of the meters.

The fires will be attended to by the exhibitors, and managed as they may think proper. The water level will be fixed at a proper height, and a thread tied around the gauge-glass at that point, its height above the bottom of the glass being recorded; and the water will be kept, as nearly as possible, at that point. At the termination of twelve hours from the commencement of the trial, the stop valve will be shut, and the fires hauled. The exhibitor may, at his discretion, allow his fires to burn down toward the close of the trial; and will be credited, in any case, with the fuel remaining on the grate.

A Davis recording gauge, and, if possible, an Edson gauge, will be attached, and their record handed to the Committee at the close of each test.

The Committee will, at their own discretion, decline to proceed in any test where all the prescribed preliminaries have not been complied with; and will, should they consider it proper, throw out any test which has evidently not been conducted as directed.

After the trials all apparatus will be again tested, and measurements of heating and grate surfaces revised.

Very respectfully,

R. H. THURSTON,

Chairman.

SUPPLEMENTARY LETTER.

FAIR OF AMERICAN INSTITUTE,

November 9th, 1871.

To the Superintendent of Machinery:

SIR,—It having been found necessary to change the position of the meter which is to measure the quantity of injection water used during the proposed test of steam boilers, and as it is now arranged so as to measure the entering stream, the following method of operation with respect to the supply of injection, etc., will be adopted:

At the beginning of each trial the injection will remain shut off until the temperature of the surface water in the tank has reached one hundred and fifty (150) degrees Fahrenheit, when the injection will be turned on.

At the close of the test, after the steam has ceased entering the condenser from the boiler on trial, the injection will remain open until it is found that the water entering and that leaving the tank have about the same temperature, and evidence is thus given that all of the heat received from the boiler has been taken away and mea-

ured. During this latter interval, the temperatures of injection and of discharge will be measured at as frequent intervals as the Judges or their representatives may consider necessary for accurate determination of the quantity of heat passing off.

The tank for measuring the water of condensation having been found to leak seriously, you will substitute for it a vessel in which the water may be caught and accurately weighed.

You will see the precaution taken to open the injection cock as little as possible, in order to use the least quantity of water consistent with complete condensation of steam.

Very respectfully, yours,

R. H. THURSTON,

Chairman, for the Committee.

The Root boiler was first connected with the condenser, and its trial commenced, November 10th. But it was found that the boiler could furnish more steam than the safety-valve, through which the steam was intended to blow off into the condenser, could pass. It became necessary, therefore, to allow the steam to pass directly through a stop-valve into the condenser. This interrupted the trial for the day, and advantage was taken of the opportunity thus offered to remedy all of the minor defects that had been discovered.

On November 13th the trial of the Root boiler was made without mishap, continuing through twelve hours, as proposed; on the 14th the Allen boiler was tried; on the 15th the Phleger; and on the 16th the Lowe. After a series of mishaps, the Blanchard boiler was also finally tested successfully on November 21st.

We annex the record, given by the logs, in exhibits A, B, C, D and E.

* * * * * * * *

CALCULATIONS.

All calculations are given in detail, in exhibits F, G, H, I and J.

In calculating the results from the record of the logs, the Committee first determined the amount of heat caried away by the condensing water, by deducting the temperature at which it entered from that at which it passed off.

To this quantity is added the heat which was carried away by evaporation from the surface of the tank, as determined by placing a cup of water in the tank at the top of the condenser, at such height that the level of the water inside and outside the cup were the same, not-

ing the difference of temperatures of the water in the cup and at the overflow, and the loss by evaporation from the cup. The amount of evaporation from the surface of the water in the cup and in the condenser, which latter was exposed to the air, was considered as approximately proportional to the tension of vapor due their temperatures, and was so taken in the estimate. The excess of heat in the water of condensation over that in the feed water, also evidently came from the fuel, and this quantity was also added to those already mentioned.

The total quantities were, in thermal units, as follows:

Root,	34,072,058·09
Allen,	48,241,833·60
Phleger,	24,004,601·14
Lowe,	38,737,217·57
Blanchard,	11,951,002·10

These quantities being divided by the weight of combustible used in each boiler during the test, will give a measure of their relative economical efficiency; and divided by the number of square feet of heating surface, will indicate their relative capacity for making steam. But as it is the intention of the Committee to endeavor to establish a practically correct measure that shall serve as a standard of comparison in subsequent trials, it is advisable to correct these amounts by ascertaining how and where errors have entered, and introducing the proper correction.

There were two sources of error that are considered to have affected the result as above obtained. The tank being of wood, a considerable quantity of water entering it, leaked out again at the bottom, without increase of temperature, instead of passing through the tank and carrying away heat, as it is assumed to have done in the above calculation. The meters also have registered rather more water than actually passed through them, and this excess assists in making the above figures too high. The sum of these errors, the Committee, after a careful consideration of the several logs, and inspection of the apparatus, have estimated at four (4) *per centum* of the total quantity of heat carried away by the condensing water. The other two quantities are considered very nearly correct.

Making these deductions, we have the following as the total heat, in British thermal units, which was thrown into the condenser by each boiler:

Root,	32,751,834.34
Allen,	46,387,827.10

Phleger,	23,066,685.39
Lowe,	37,228,739.07
Blanchard,	11,485,777.35

That the figures thus obtained are very accurate, is shown by calculating the heat transferred to the condenser by the Root and the Allen boilers (both of which superheated their steam,) by basing the calculation on the temperature of the steam in the boiler as given by the thermometer, the results thus obtained being 32,723,681.76 and 46,483,322.5, respectively.

Dividing these totals by the pounds of combustible consumed by each boiler, we get, as the quantity of heat per pound, and as *a measure of the relative economic efficiency:*

Root,	10,281.53
Allen,	10,246.92
Phleger,	10,143.66
Lowe,	10,048.24
Blanchard,	10,964.94

Determining the weight, in pounds, of water evaporated per square foot of heating surface per hour, we get, as *a measure of the steaming capacity:*

Root,	2 65
Allen,	3.59
Phleger,	2.83
Lowe,	3.10
Blanchard,	1.92

It is but right to remark here that, as is indicated by the log, the fires in the Root boiler were allowed, at one time, to get much too low, and it is supposed that the standing of that boiler was thus seriously impaired. The fires of the Lowe boilers were undisturbed during the whole trial, its position, also, being thus lowered.

The quantity of heat per pound of combustible, as above determined, being divided by the latent heat of steam at 212° Fahr. (966°.6), gives, as *the equivalent evaporation of water at the pressure of the atmosphere, and with the feed at a temperature of* 212° *Fahr.:*

Root,	10.64
Allen,	10.60
Phleger,	10.49
Lowe,	10.40
Blanchard,	11.34

For general purposes, this is the most useful method of comparison for economy.

The above figures afford a means of comparison of the boilers, irrespective of the condition (wet or dry) of the steam furnished by them. All other things being equal, however, the Committee consider that boiler to excel which furnishes the dryest steam; provided that the superheating, if any, does not exceed about 100° Fahrenheit.

In this trial *the superheating* was as follows:

Root,	16°.08
Allen,	18°.23
Phleger,	0°.
Lowe,	0°.
Blanchard,	0°.

As the Blanchard, Phleger and the Lowe boilers did not superheat, it becomes an interesting and important problem to determine the quantity of water carried over by each with the steam. This we are able, by the method adopted, to determine with great facility and accuracy.

Each pound of saturated steam transferred to the condensing water the quantity of heat which had been required to raise it from the temperature of the water of condensation to that due to the pressure at which it left the boiler, *plus* the heat required to evaporate it at that temperature.

Each pound of water gives up only the quantity of heat required to raise it from the temperature of the water of condensation to that of the steam with which it is mingled.

The total amount of heat is made up of two quantities, therefore, and a very simple algebraic equation may be constructed, which shall express the condition of the problem:

Let H = heat units transferred per pound of steam.
h = heat units transferred per pound of water.
U = total quantity of heat transfered to condenser.
W = total weight of steam and water, or of feed water.
x = total weight of steam.
$W-x$ = total weight of water primed.

Then $H\,x+h\,(W-x)=U$; or, $x=\dfrac{\frac{U}{h}-W}{\frac{H}{h}-1}$

Substituting the proper values in this equation, we determine *the absolute weights and per centages of steam and water* delivered by the several boilers to be as follows:

	Weight of steam.	Weight of water.	Per centage of water primed to water evaporated.
Root,	27,896.	0.	0.
Allen,	39,670.	0.	0.
Phleger,	19,782.94	645.06	3.26
Lowe,	31,663 35	2,336.65	6.9
Blanchard,	9.855.6	296.9	3.

And *the amount of water, in pounds, actually evaporated per pound of combustible:*

Root,	8.76
Allen,	8.76
Phleger,	8.70
Lowe,	8.55
Blanchard,	9.41

Comparing the above results, the Committee are enabled to state the following order of capacity and of economy, in the boilers exhibited, and their relative per centage of useful effect, as compared with the economical value of a steam boiler that should utilize all of the heat contained in the fuel:

	Steaming capacity.	Economy of fuel.	Per centage of economical effect.
Root,	No. 4	No. 2	0.709
Allen,	" 1	" 3	0.707
Phleger,	" 3	" 4	0.699
Lowe,	" 2	" 5	0.693
Blanchard,	" 5	" 1	0.756

The results obtained, as above, and other very useful determinations derived from this extremely interesting trial, are given in the following table, which the Committee hope and anticipate may be found, by all who are interested in the subject, to be of very great value as a reliable record of the trial of several excellent steam boilers, as a valuable *standard set of data* with which to compare the results of future trials, and as a useful aid in judging of the accuracy of statements made by boiler venders in the endeavor to effect sales by presenting extravagant claims of economy in fuel.

The Committee regret that the log of the trial of the Blanchard boiler was very carelessly kept, but they believe that the method adopted afforded such a perfect system of checks that no appreciable error was introduced.

They desire to express their appreciation of the neatness and efficiency of the arrangement by which provision is made, in the Lowe

Results of the competitive trial of Steam Boilers at the Fair of the American Institute, November, 1871.

NAME.	Square Feet.		Ratio of heating surface to the grate surface.	Total Weights.					Ratio of water primed to water evaporated.	Mean Temperatures.						
	Grate surface.	Heating surface.		Coal.	Combustible.	Feed.	Steam.	Primed water.		Injection.	Feed.	Water of condensation.	Discharge.	Steam.	Super heat.	Flues.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.	P.
Root	27	876½	32.5	3800	3185.5	27896	27896	0.	0.	45°.94	45°.94	58°.31	143°.1	334°.6	16°.08	416°.6
Allen	32¼	920	28.5	5375	4527	39670	39670	0.	0.	45°.5	45°.5	63°.48	154°.76	330°.63	13°.23	345°.87
Phleger	23	600	26.1	2800	2274	20428	19782.94	645.06	3.26	45°.65	45°.65	54°.38	120°.83	321°.06	0°.	503°.76
Lowe	37¾	912	24.2	4400	3705	34000	31668.35	2336.65	6.9	45°.0	45°.0	54°.8	131°.5	319°.48	0°.	389°.6
Blanchard	8½	440	51.8	1232	1047.5	10152.5	9855.6	296.9	3	44°.4	44°.4	49°.49	106°.14	323°.75	0°.	221°.67

Results, etc.—(Continued.)

NAME.	Total British thermal units.	Total units per pound of combustible.	Apparent Evaporation.				Actual Evaporation.		Equivalent evaporation of water at 212° Fahr. and atmospheric pressure.	Square feet of heating surface required to evaporate one cubic foot of water per hour.	Coal, lbs. per square foot, grate surface per hour.	Efficiency; actual evaporation of fuel divided by theoretical.
			Per pound of coal.	Per pound of combustible.	Per square foot grate surface per hour.	Per square foot of heating surface per hour.	Per pound of coal.	Per pound of combustible.				
	Q.	R.	S.	T.	U.	V.	W.	X.	Y.	Z.	Z. 1	Z. 2
Root	32,751,834.34	10,281.53	7.34	8.76	86.09	2.65	7.34	8.76	10.64	23.59	11.73	0.709
Allen	46,387,827.1	10,246.92	7.38	8.76	102.51	3.59	7.38	8.76	10.60	17.41	13.88	0.707
Phleger	23,066,685.39	10,143.66	7.26	8.95	73.70	2.83	7.07	8.70	10.49	22.74	10.13	0 699
Lowe	37,228,739.072	10,048.24	7.68	9.12	75.06	3.10	7.39	8.55	10.40	21.63	9.71	0.693
Blanchard	11,485,777.35	10,964.94	8.24	9.60	99.53	1.92	8.00	9.41	11.34	33.48	12.10	0.756

boiler, for complete combustion of the furnace gases, and of the excellent general arrangement and proportions which gave to the Allen boiler its remarkable high steaming capacity.

As some authorities consider the evaporation of one cubic foot per hour to be the equivalent of one-horse power, column Z is introduced to give the area of heating surface required in each boiler, per horse-power, on this basis. *A good, modern steam engine* ought not to require more than one-half the specified amount.

The Committee conclude with an expression of the hope that the American Institute will make such tests of boilers a regular feature of its annual exhibitions, and that a standard set of apparatus, such as was here used, will be built, every possible precaution being taken to insure accuracy and delicacy in the instruments provided.

The Committee think that such action would confer a great benefit upon the country and upon the Institute, and that pecuniarily it would be also of advantage to the Institute, which should make a moderate charge to exhibitors for its use.

The report is signed by Professor R. H. THURSTON, Chairman; THOS. J. SLOAN and ROBERT WEIR.

WOOD-WORKING MACHINERY.

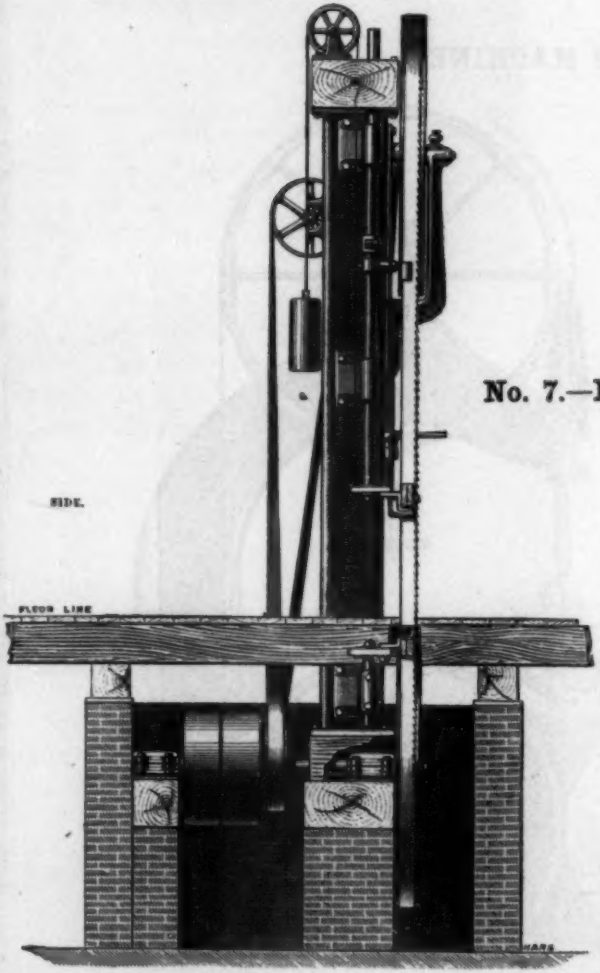
A treatise on its construction and application, with a history of its origin and progress. By J. RICHARDS, M. E.

(Continued from page 268).

Having in the preceding articles that have appeared in the *Journal* noticed, in succession, the popular machines in use for sawing, planing, cutting, boring, turning, etc., attention must in future be devoted to new machines, and to the progress of the "art," since these articles commenced.

Although not two years ago, the changes and improvements, both in this and foreign countries, has exceeded what was then predicted, and very fully confirms the position then assumed, as to the then imperfect character of machines of this class, when compared with engineering implements and manufacturing machinery generally.

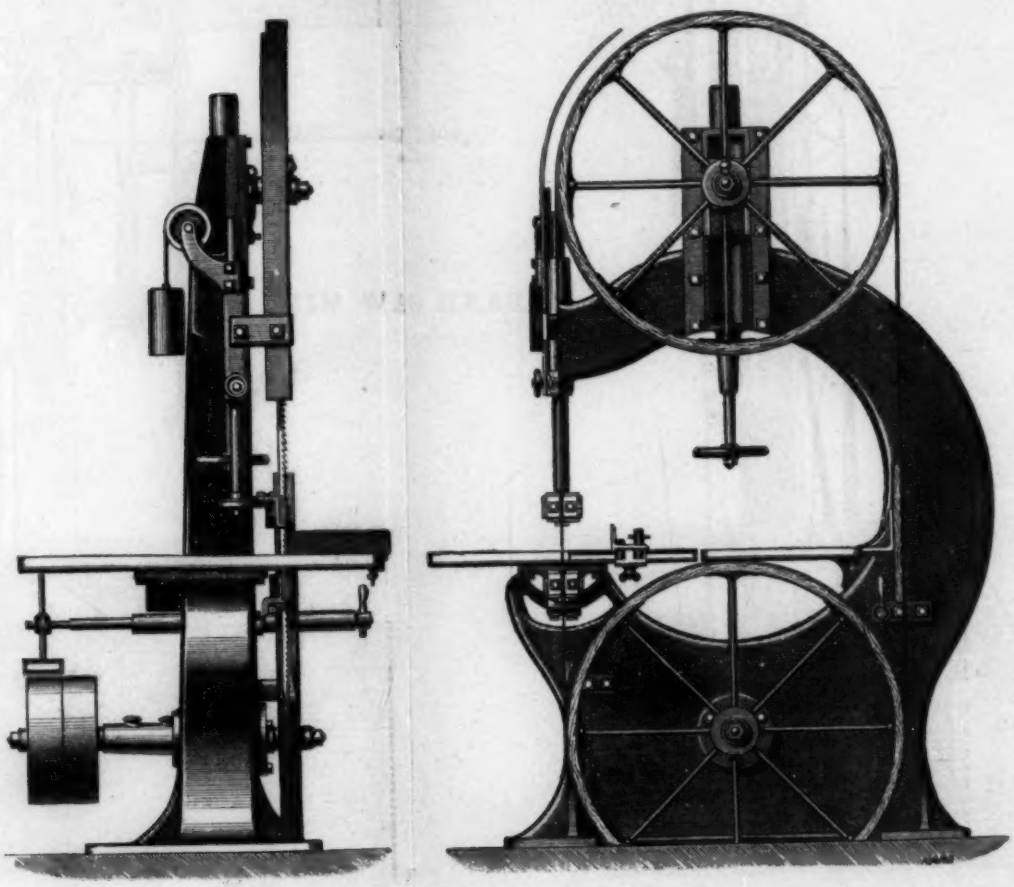
In France, the manufacture of wood-cutting machines is, as a branch of engineering, quite as well developed as that of machines for cutting and shaping metal, a fact that is exceptional, and applies to no other part of the world. This is the more creditable when we consider that it is but ten years since the business was founded to an extent that



No. 7.—BAND SAW MILL.

BUILT AT THE "ATLANTIC WOR

No. 3—BAND SAWING MACHINE.



entitled it to be called a branch of engineering, and to the farther fact that it is yet but a limited interest—compared to most other kinds of engineering work.

It should perhaps in this connection be explained that the manufacture of machinists' tools, with which we institute the comparison, has not kept pace with those of England and America. The highest talent in both these latter countries has, for nearly a half century past, been directed to the perfecting of machines for turning, planing, boring and shaping metals, and while the French have not been slow in following the precedents established, and have indeed added much, yet their progress has been but slow in comparison.

F. Arbey and M. Perin, of Paris, in their designs for wood-cutting machines, exhibit a boldness and originality that is not to be found among engineers in other branches. It is hoped that we will in time be able to give to the readers of the *Journal* some examples of the practice of M. Arbey, which will no doubt be of interest.

For engravings we present in this No., at fig. 1, true elevations of a Band Sawing Mill for timber drawn to a scale of $\frac{1}{48}$th $\frac{1}{2}''=1'$. The scale, it must be noticed, is a small one, and will, unless considered, convey an incorrect impression of the size of the machine, which is larger, with one exception, than any that has hitherto been made for this or any other purpose.

The wheels are of wrought iron, faced with wood, and covered with leather; their diameter over all being six feet. The blades are 45 feet long and five inches wide. The top shaft is supported both behind and in front of the top wheel; is of steel, three and a half inches in diameter. The lower shaft is four and a half inches diameter, with bearings twelve inches long. The guide stem is three and a half inches diameter, counterweighted, and carried in iron brackets bolted to the main column.

The mill is furnished either with feeding rolls for re-sawing lumber, or with a carriage for cutting timber, or with both, as may be wanted. The diagram on the right of the front elevation merely indicates the position of the log when arranged for timber-sawing. The engraving is intended only to illustrate the band-sawing mechanism. The vertical adjustment of the top wheel is twenty inches, with elastic tension of the blades to equalize the strain. Weight about three and one half tons.

Fig. 2, shows elevations of a new band-sawing machine for cutting straight, curved or bevel lines by hand, and corresponds in its arrange-

ment to our illustration in a former number, except that the throat is to the left instead of right hand, and that it is a much heavier machine. The wheels are 44 inches diameter, made of wrought iron and wood, the bearings are brass, shafts steel, and the whole fitted to meet the nice requirements of band-sawing. The scale is $\frac{1}{24}$th $\frac{1}{2}''=1'$; weight about one and one half tons.

These two examples are from the machines of Messrs. Richards, London, and Kelley, of this city.

EXPERIMENTS ON VARIOUS COALS OF THE CARBONIFEROUS AND CRETACEOUS PERIODS,

To Ascertain their Relative Potential and Economic Vaporizations. Made by Chief Engineer B. F. Isherwood, *U. S. Navy, at the Mare Island Navy Yard, California, in* 1871.

The experiments described in this report on the vaporizative efficiencies of several kinds of coal, were made by the writer when he was Chief Engineer of the Mare Island Navy Yard, California, and embraced trials of all the varieties of which he could obtain a sufficient quantity. Previous to these experiments, nothing was known with regard to their relative value for steam generation, and the most erroneous opinions prevailed on the subject.

The coals experimented with belong to two geological periods, viz., the carboniferous and the cretaceous. Of the former are the anthracite from the Scranton mines, of Luzerne County, Pennsylvania, the Anthracitic coal from the western part of Wales, and the semi-bituminous coal from the Cumberland mines of Maryland. They are true coals, are extensively used, and have, for equal weights, the greatest steam-generating efficiency of any known, for which reasons they were experimented with to furnish a standard of comparison for the unknown coals of the latter period—a much more recent one than the carboniferous.

The coals of the cretaceous period experimented with, with the exception of the anthracite from Queen Charlotte Island, are what are called "brown coals." They are composed of exactly the same constituents as those of the carboniferous period, but in very different proportions; and these proportions vary, too, according as the coal belongs to the miocene or to the upper tertiary strata. To the latter belong the coals of Wyoming Territory and of California: while the remaining brown coals from Oregon, Washington Territory, Vancouver Island and Australia, belong to the former, and have their analo-

gues in the brown coals of Germany. The coal of Queen Charlotte Island is a brown coal transformed into anthracite by the heat and pressure of a mountain upheaval.

The coals of Vancouver Island, Washington Territory, Oregon and California, were from that portion of the Pacific Coast range of mountains which is comprised between British Columbia on the north and San Francisco on the south. Queen Charlotte Island lies off the northern part of British Columbia, and belongs to Great Britain. The coal of Wyoming Territory was from the Wahsatch Range or spur of the Rocky Mountains, and the mine is situate about 80 miles northeast of Great Salt Lake. The Australian coal was from the eastern coast of Australia, near Sidney, from which port in New South Wales it was shipped.

The following are the detailed descriptions of the different coals experimented with:

Pennsylvania Anthracite.

The specimen of this coal from the Scranton mines scarcely soiled the hand by contact, and possessed great cohesion, requiring strong blows from a hammer to break moderate-sized lumps. Its fracture was semi-conchoidal, the color a brilliant jet, the lustre almost metallic. It ignited with difficulty, burned slowly, and entirely by the surfaces, and gave out an intense heat. The lumps neither softened, swelled, nor agglutinated. At the commencement of the combustion there was a slight development of a very faint bluish flame, which soon passed to a faint yellow and quickly disappeared, leaving the incandescent fixed carbon alone. No smoke was at any time produced.

The following was the chemical composition of this anthracite in units of weight, *inclusive* of its hygrometric moisture, ash and clinker:

Carbon,	78·54
Hydrogen,	2.52
Oxygen,	1·68
Nitrogen,	0·84
Sulphur,	0·42
Hygrometric moisture,	1·16
Ash and clinker,	14·84
	100·00

Exclusive of hygrometric moisture, ash and clinker, the chemical composition in units of weight was as follows:

Carbon,	93·5
Hydrogen,	3·0
Oxygen,	2·0
Nitrogen,	1·0
Sulphur,	0.5
	100·00

The specific gravity of this anthracite was 1·453.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 70 per centum were ash and 30 per centum clinker. The specific gravity of the clinker was 1·931.

One cubic foot of this anthracite in the merchantable state weighed 58·82 pounds, of which bulk the solid matter occupied 64·89 per centum and the interstitial spaces 35·11 per centum. To stow one ton of this coal, 38·08 cubic feet are required.

One cubic foot of the ash weighed 56·47 pounds; and one cubic foot of the clinker weighed 40·00.

Queen Charlotte Island Anthracite.

The anthracite from Queen Charlotte Island, off the northern portion of the Pacific coast of British Columbia, was identical in chemical composition with the Scranton anthracite, excepting the proportion of earthy matter, which was greatly larger. In appearance, mechanical properties, and mode of combustion in the furnace, it was exactly like the Scranton anthracite. The following was its chemical composition in units of weight, *inclusive* of its hygrometric moisture, ash and clinker:

Carbon,	55·54
Hydrogen,	1·78
Oxygen,	1·19
Nitrogen,	0·59
Sulphur,	0·30
Hygrometric moisture,	0·85
Ash and clinker,	39·75
	100·00

The specific gravity of this anthracite was 1·508.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 63·53 per centum were ash, and 86·47 per centum clinker. The specific gravity of the clinker was 2·052.

One cubic foot of this anthracite in the merchantable state weighed 64·70 pounds, of which bulk the solid matter occupied 68·77 per centum, and the interstitial spaces 31·23 per centum. To stow one ton of this coal 34·62 cubic feet are required.

One cubic foot of the ash weighed 51·41 pounds; and one cubic foot of the clinker weighed 46·35 pounds.

Welsh Anthracite.

The anthracitic coal from the western portion of Wales, was intermediate in its characteristics between anthracite and semi-bituminous coal. It was lamellated of alternate streaks of dull black and shining jet; the latter streaks exactly resembling anthracite, being hard and not soiling the hand; while the former streaks resembled semi-bituminous coal, being moderately friable and easily soiling the hand. This coal kindled with difficulty, and burned even more slowly than the anthracite, but with more flame, which was, however, of a faint yellowish color, and entirely free of smoke. The lumps did not intumesce or cohere, but they did not preserve their form as completely as in the case of the anthracite.

The following was the chemical composition of this coal in units of weight, *exclusive* of its hygrometric moisture, ash and clinker:

Carbon,	91·5
Hydrogen,	4·0
Oxygen,	2·5
Nitrogen,	1.0
Sulphur,	1·0
	100·0

Inclusive of hygrometric moisture, ash and clinker, the chemical composition in units of weight was as follows:

Carbon,	84·18
Hydrogen,	3·68
Oxygen,	2·30
Nitrogen,	0·92
Sulphur,	0·92
Hygrometric moisture,	1·27
Ash and clinker,	6·73
	100·00

The specific gravity of this anthracitic coal was 1·390.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 85·16 per centum were ash, and 14·84 per centum clinker.

One cubic foot of this coal in the merchantable state weighed 56·85 pounds, of which bulk the solid matter occupied 65·55 per centum, and the interstitial spaces 34·45 per centum. To stow one ton of this coal 39·40 cubic feet are required.

One cubic foot of the ash weighed 34·60 pounds.

Semi-Bituminous Coal.

The semi-bituminous coal experimented with, was from the Cumberland mines of Maryland. It ignited readily, and burned freely with a red flame of medium length, giving off a moderate quantity of semi-transparent brown smoke. It contained but a small amount of volatile matter, which was soon expelled, and the remaining mass quickly acquired the temperature of full ignition. The lumps of this coal, while parting with their volatile elements, lost their shape, agglutinated slightly, and intumesced considerably, forming a very porous coke, which underwent rapid and complete combustion. This coal, by reason of at first slightly cohering in the furnace, needed, at the commencement of its combustion, occasional breaking up on top with the firing-tools.

The physical structure of the semi-bituminous coal is chiefly columnar, passing sometimes into slaty. The columnar portions are semi-crystalline, while the slaty ones are amorphous; the former exhibit a deep shining jet, the latter are dull black. The cohesion is weak; the slightest blow causes fracture, the surface of which is frequently striated, and in all casts much soils the hand. The smallest mechanical action crumbles the lumps into fine powder.

The following was the chemical composition of this coal in units of weight, *inclusive* of its hygrometric moisture, ash and clinker:

Carbon,	80·55
Hydrogen,	4·50
Oxygen,	2·70
Nitrogen,	1·08
Sulphur,	1·17
Hygrometric moisture,	1·75
Ash and clinker,	8·25
	100·00

Exclusive of hygrometric moisture, ash and clinker, the chemical composition in units of weight was as follows:

Carbon,	89·5
Hydrogen,	5·0
Oxygen,	3·0
Nitrogen,	1·2
Sulphur,	1·3
	100·0

The specific gravity of this semi-bituminous coal was 1·332.

Of the earthy matter remaining after combustion, and composed of

ash and clinker, 85·16 per centum were ash, and 14·84 per centum clinker. The specific gravity of the clinker was 1·820.

One cubic foot of this semi-bituminous coal in the merchantable state weighed 55·65 pounds, of which bulk the solid matter occupied 66·97 per centum, and the interstitial spaces 33·03 per centum. To stow one ton of this coal, 40·25 cubic feet are required.

One cubic foot of the ash weighed 32·00 pounds; and one cubic foot of the clinker weighed 38·85.

Brown Coal.

The name of brown coal is given to the fossil carbonaceous deposits of the cretaceous period, which are of more remote origin, and have been subjected to greater heat and pressure than the lignites. This coal cannot be discriminated by the eye from the true coals or those of the carboniferous period, from which they differ principally in their larger proportion of oxygen and hygrometric moisture, in which respect they seem to occupy an intermediate position between the lignites and true coals, though even among the brown coals the proportion of oxygen and moisture varies considerably.

Of the brown coals experimented with, that of Australia more nearly approached the true coals in chemical composition; after which came the Nanaimo coal from Vancouver Island, and the Bellingham Bay coal. The remainder were identical with each other in chemical composition, exclusive of ash and hygrometric moisture, the latter varying slightly.

All the brown coals experimented with were alike in their physical characteristics and in their behavior in the furnace. They ignited with facility and burned with much rapidity, giving off copious volumes of heavy black smoke, from which the soot fell in a shower of flakes. During combustion, the lumps swelled slightly, lost their form, and coked, but did not agglutinate; the flame was long, very dense, and yellowish-white.

Brown coal divides into cubical lumps, which have a considerable degree of hardness, so that a smart blow from a hammer is required to break them. They have a coarse-grained appearance, and a very irregular fracture not in the least conchoidal. They are composed of thin laminæ, and present a dull grayish black color, soiling the hand much by contact. When subjected to heat, they quickly fall into very small pieces, which escape between the grate-bars, unless those spaces are made very narrow.

Australian Brown Coal.

Two samples of Australian brown coal were experimented with. The "first sample" was of very superior quality; the "second sample" was a fair average of what is supplied to the market. The difference in their caloric effect was very great; for, in the "first sample," it exceeded that in the "second sample" 18½ per centum. The following is the chemical composition of the two samples in units of weight, *inclusive* of hygrometric moisture, ash and clinker:

	First Sample.	Second Sample.
Carbon,	74·02	64·25
Hydrogen,	4·78	4·15
Oxygen,	7·47	10·00
Nitrogen,	1·11	1.00
Sulphur,	0·62	0·60
Hygrometric moisture,	3·93	10·00
Ash and clinker,	8·07	10·00
	100·00	100·00

Exclusive of hygrometric moisture, ash and clinker, the chemical composition in units of weight was as follows:

	First Sample.	Second Sample.
Carbon,	84·11	80·31
Hydrogen,	5·43	5·19
Oxygen,	8.49	12·50
Nitrogen,	1·56	1·25
Sulphur,	0·71	0·75
	100·00	100·00

The specific gravity of the Australian brown coal was 1·275.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 64·22 per centum were ash, and 35·78 per centum clinker. The specific gravity of the clinker was 1·852.

One cubic foot of this brown coal in the merchantable state weighed 54·12 pounds, of which bulk the solid matter occupied 68·04 per centum and the interstitial spaces 31·96 per centum. To stow one ton of this coal, 41·39 cubic feet are required.

One cubic foot of the ash weighed 34·50 pounds; and one cubic foot of the clinker weighed 40·24 pounds.

BROWN COAL FROM THE WAHSATCH RANGE OF THE ROCKY MOUNTAINS; FROM THE MOUNT DIABLO MINES OF CALIFORNIA; FROM COOSE BAY, OREGON; AND FROM SEATTLE, ON PUGET SOUND, WASHINGTON TERRITORY.

The brown coals from the Wahsatch Range of the Rocky Mountains in Wyoming Territory; from the mines of Mount Diablo, in California; from Coose Bay, in Oregon; and from Seattle, on Puget Sound, in Washington Territory, had identically the same chemical composition, exclusive of hygrometric moisture, ash and clinker, in which latter particulars they slightly varied.

Their chemical composition, *exclusive* of hygrometric moisture, ash and clinker, were as follows, in units of weight:

Carbon,	71·5
Hydrogen,	5·5
Oxygen,	19·5
Nitrogen,	1·3
Sulphur,	2·2
	100·0

The following is their mean chemical composition in units of weight, *inclusive* of hygrometric moisture, ash and clinker, namely:

Carbon,	50.05
Hydrogen,	3·85
Oxygen,	13·65
Nitrogen,	0·91
Sulphur,	1·54
Hygrometric moisture,	16·82
Ash and clinker,	13·18
	100·00

The specific gravity of these brown coals was 1·320.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 69·18 per centum were ash, and 30·82 per centum were clinker. The specific gravity of the clinker was 1·774.

One cubic foot of these brown coals in the merchantable state weighed 53·36 pounds, of which bulk the solid matter occupied 64·79 per centum, and the interstitial spaces 35·21 per centum. To stow one ton of these coals, 41·98 cubic feet are required.

One cubic foot of the ash weighed 39·41 pounds; and one cubic foot of the clinker weighed 37·73 pounds.

BROWN COAL FROM BELLINGHAM BAY, WASHINGTON TERRITORY.

The brown coal of Bellingham Bay is the extreme northwest corner of Washington Territory, immediately opposite the Nanaimo

mines of Vancouver Island, from which it is separated by a narrow strait of water. Though but another part of the Nanaimo vein, the Bellingham Bay coal is inferior in calorific value to that from those mines, principally because it is a surface coal, and contains, consequently, a much greater proportion of hygrometric moisture, ash and clinker, while the Nanaimo mines have been long worked, and to a very considerable depth. The chemical composition of both coals, *exclusive* of the hygrometric moisture, ash and clinker, is exactly the same, and as follows, in units of weight, namely:

Carbon,	75·5
Hydrogen,	5·3
Oxygen,	14·0
Nitrogen,	1·3
Sulphur,	1·9
	100·0

The chemical composition of the Bellingham Bay coal, *inclusive* of its hygrometric moisture, ash and clinker, is as follows, in units of weight, namely:

Carbon,	49·60
Hydrogen,	3·39.
Oxygen,	8·96
Nitrogen,	0·83
Sulphur,	1·22
Hygrometric moisture,	12.52
Ash and clinker,	23·48
	100·00

The specific gravity of the Bellingham Bay coal was 1·350.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 72·35 per centum were ash, and 27·65 per centum clinker. The specific gravity of the clinker was 1·794.

One cubic foot of this brown coal in the merchantable state weighed 60·70 pounds, of which bulk the solid matter occupied 72·07 per centum, and the interstitial spaces 27·93 per centum. To stow one ton of this coal 36·90 cubic feet are required.

One cubic foot of the ash weighed 39·00 pounds; and one cubic foot of the clinker weighed 32·00 pounds.

Nanaimo Brown Coal.

This coal is from the Nanaimo mines, on the southeastern portion of Vancouver Island, British Columbia, and about seventy miles north of the city of Victoria. These mines (1871) are three in number.

One is on a small island called Newcastle Island, separated from Vancouver Island by a strait about one-eighth of a mile wide; the other two, called No. 3 Pit and Parkhead Level and Slope, are on Vancouver. Only the Newcastle Island mine has been extensively worked, and from it came the coal on which the experiments were made.

The physical character of the clinker of this coal varied greatly with the rate of combustion. At the maximum rate (18,397 pounds of coal per square foot of grate surface per hour), the clinker was very fusible and highly vitreous, running down between the grate-bars into the ash-pit in the consistence of stiff tar, and cooling there to a jet black glossy substance, very brittle, and highly conchoidal in fracture. This clinker when on the grates was of tarry stickiness, and very difficult of removal by the slice-bar. At the medium rate of combustion (12,642 pounds of coal per square foot of grate surface per hour), the character of the clinker entirely changed; it lost its vitreous appearance and tarry consistency, came easily from the grate-bars when hot, and was no longer fusible. At this rate of combustion, the clinker was no more objectionable than that from the best steam-coals.

The chemical composition of the Nanaimo coal, *exclusive* of the hygrometric moisture, ash and clinker, is as follows, in units of weight, namely:

Carbon,	77·5
Hydrogen,	5·3
Oxygen,	14·0
Nitrogen,	1·3
Sulphur,	1·9
	100·0

The chemical composition of the Nanaimo coal, *inclusive* of the hygrometric moisture, ash and clinker, are as follows, in units of weight, namely:

Carbon,	59·68
Hydrogen,	4·08
Oxygen,	10·78
Nitrogen,	1·00
Sulphur,	1·46
Hygrometric moisture,	10·26
Ash and clinker,	12·74
	100·00

The specific gravity of the Nanaimo coal was 1·302.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 59·54 per centum were ash and 40·46 per centum clinker. The specific gravity of the clinker from the maximum rate of combustion was 2·279; and from the medium rate of combustion, 2·444.

One cubic foot of the Nanaimo coal in the merchantable state weighed 51·77 pounds, of which bulk the solid matter occupied 63·73 per centum, and the interstitial spaces 36·27 per centum. To stow one ton of this coal, 43·27 cubic feet are required.

One cubic foot of the ash weighed 48·71 pounds. One cubic foot of the clinker from the maximum rate of combustion weighed 51·53 pounds; and one cubic foot of the clinker from the medium rate of combustion weighed 43·77 pounds.

Coke from the Nanaimo Coal.

The brown coals are very inferior producers of coke and illuminating gas, to the semi-bituminous and bituminous coals of the carboniferous period; and the inferiority is in both quantity and quality. The coke experimented with was made from the Nanaimo coal by subjecting it to destructive distillation in the retorts of the San Francisco gas works. It was extremely porous, very hygrometric, not very hard, and amounted in weight to 43 per centum of the coal from which it was made. It contained 13·85 per centum of ash and clinker, and 13 per centum of hygrometric moisture, by weight. The specific gravity of the coke was 0·868.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 47·79 per centum were ash, and 52·21 per centum clinker. The specific gravity of the clinker was 2·488.

One cubic foot of this coke in the merchantable state weighed 28 pounds, of which bulk the solid matter occupied 51·70 per centum, and the interstitial spaces 48·30 per centum. To stow one ton of this coke, 80 cubic feet are required.

One cubic foot of the ash weighed 44·47 pounds; and one cubic foot of the clinker weighed 48·70 pounds.

The experiments on the coals and coke above described were made with the spare boiler for supplying the machine-shop engine; the description of which, as well as the plan of the experiments, will follow in subsequent numbers.

THE GUNPOWDER PILE DRIVER.

(Report upon its Operation at the New Landing Wharf at League Island.)

By F. C. Prindle, C. E.

Editor of Journal of the Franklin Institute:

Dear Sir—I am now able to respond to your request, and so redeem my promise to give you the results of my experience with Shaw's Gunpowder Pile Driver during its operation here in driving the piles of our new landing wharf, which part of the work has recently been completed.

From the novel application of gunpowder to pile driving, and the wide spread interest felt in the results of its practical operation in actual work, not to mention the many advantages claimed for it by its inventor, I was led at the outset to keep a complete record of its operations here, and which has been noted down on the spot by a constant and careful observer.

The wharf in process of construction is located at the foot of Broad street, and extends into the Delaware 300 feet from the embankment, by 100 feet wide, crossing the mean low-water line about half way out.

The bearing piles, which are of heavy yellow pine, are spaced 8 feet between centres lengthwise and 5 feet crosswise—the specifications requiring them to average 10 inches middle diameter, and to be firmly driven to hard bottom.

The whole number driven was 807, including mooring piles, and particular care was taken to preserve the alignment of all the rows crosswise and the outer row on each side lengthwise.

They were driven through a soft mud, containing some clay, to a very hard bottom, where they brought up firmly, and which required from six to eight "blows," with heavy charges of powder to penetrate before they could be forced any further, and then but with difficulty. This stratum—supposed to be hard clay or compact gravel—was met the whole distance, and at a nearly uniform depth of about 21 feet below mean low water.

The machine used was an entirely new one, and in some respects an experimental one, and was operated by the contractors with inexperienced hands chiefly. It was secured to a large scow in the usual manner, the latter also carrying a small engine to hoist the piles in position.

The gun, weighing 1800 lbs., has a $6\frac{1}{4}''$ bore, $24''$ deep, pointing

upwards, and is recessed at the lower end to receive the head of the pile, upon which it rests.

The ram, weighing 1300 lbs., moves in the same guides as the gun, and is provided with a piston, projecting from its lower end and neatly fitting into the bore of the gun, its upper end having a bore of greater diameter to receive a fixed piston secured to the top of the frame, and thus form an air cushion to prevent its escape from the guides when the height of its rebound is limited, as during the first blow with very long piles. The ram is caught and held at its highest ascent, and also released for the succeeding blow by the operation of a friction brake at one side pressing it against the opposite guide—all at the will of the operator on deck.

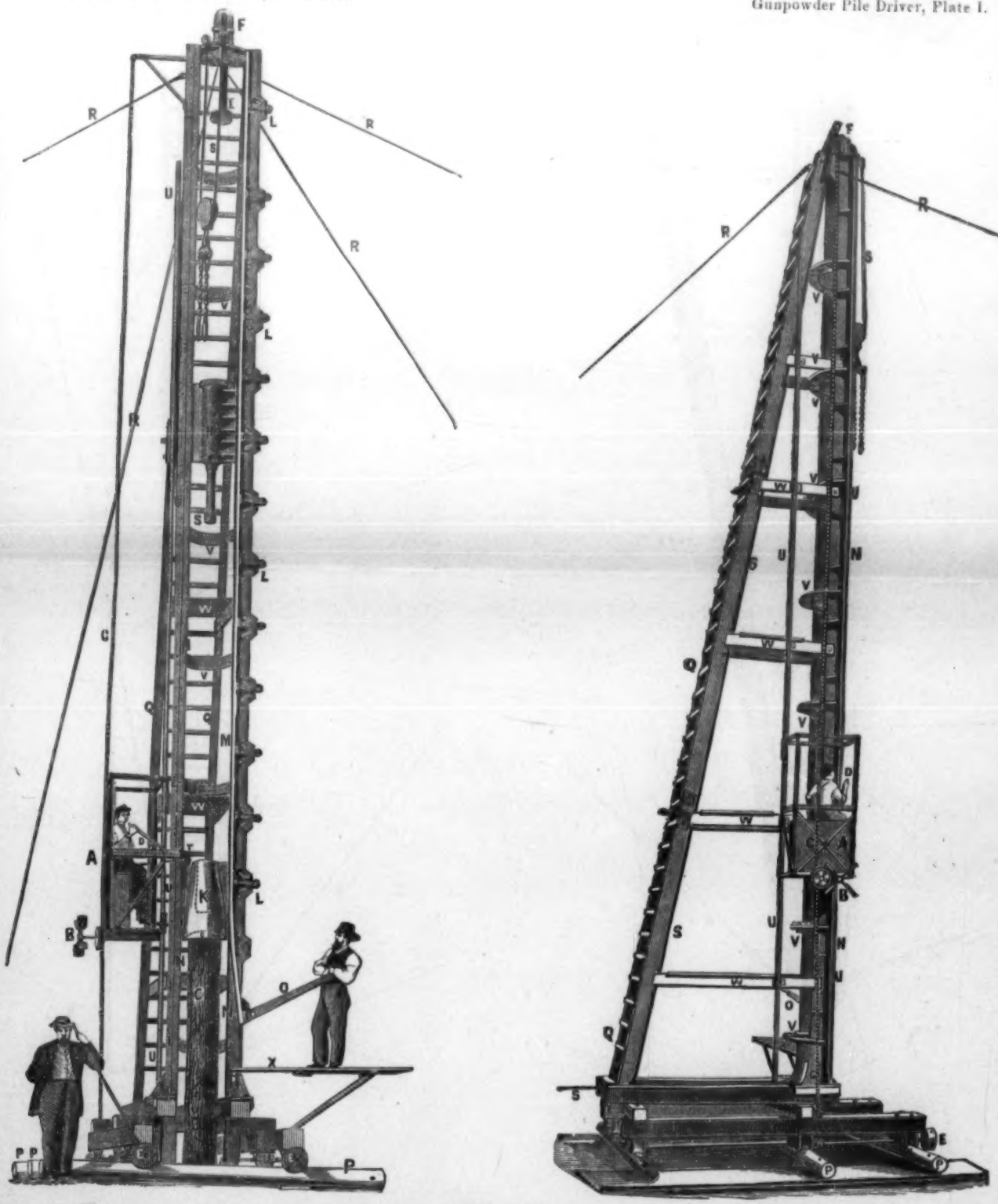
The cartridges used were made of a slow powder, cylindrical in shape ($1\frac{1}{4}''$ diameter and from $1''$ to $1\frac{1}{2}''$ long), weighing from one to one and one-half ounce each, and slightly coated with paraffine.

The first blow was generally given using an ounce cartridge, and the remainder with $1\frac{1}{4}$ or $1\frac{1}{2}$ ounce, according to size of pile, the cartridges being supplied by hand and tossed into the gun in advance of each blow.

The operation of driving is as follows: The engine hoists the ram, gun and pile into position simultaneously, with one movement; the brake is then applied, holding the ram in place, uppermost, and the gun and pile are then lowered together until the pile rests in the mud; the gun is then lowered on the top of the pile, the recess securely holding the pile-head in place directly underneath.

A cartridge is then dropped in the gun, the operator releases the brake and the ram falls with its piston entering the bore of the gun (which is made slightly funnel-shaped at the muzzle), and by compressing the air exerts a gradually increasing downward pressure upon gun and pile till the inertia of both is more or less entirely overcome, the cartridge is crushed by the piston, and ignited by the heat evolved by the sudden and severe compression of the confined air. An explosion immediately ensues, the result of which is to violently force the pile downward, and this is measured by the reactionary effort upon the ram,—the height to which it is thus thrown, and from a state of rest, practically, I suppose. The force due to the fall of the ram and the explosive force exerted to throw it again in position are thus at once combined and applied to the pile.

The principal difference of effect between this method and the ordinary hammer appears to be just here: in the one case the pile is



SHAW'S GUNPOWDER PILE DRIVER.

TABLE I.

Number of Pile.	Diameter. Inches. Bottom.	Diameter. Inches. Top.	Length of Pile. Ft	Depth driven. Ft.	Distance last blow. In.	Rebound of Ram. Ft.	Number of Blows.	Weight of Cartridge. Final. Ounces. 1	1½	1½	Number of Cartridges used. Ounces. 1	1½	1½	Time. H. M.	Date.
					Row	No	20.								1872.
					Actu	*al W*	*ork.*							P.M.	Jan'y
1	10	14	37	21	0	12	7		1		1	6		1.00	13
					Row	No.	21.								
1	9	13	36	21	1	11	7		1		1	6		1.24	"
2	9	12	32	21	6	10	5		1		1	4		1.47	"
3	9	13	35	21	1	12	5		1		1	4		1.54	"
4	9	15	35	21	0	13	8		1		1	7		2.02	"
5	9	13	34	21	1	12	6		1		1	5		2 07	"
6	9	14	35	21	1	12	6		1		1	5		2.12	"
7	9	14	35	21	4	12	6		1		1	5		2.17	"
8	9	14	35	21	2	13	8		1		1	7		2.21	"
9	8	12½	35	21	6	10	6		1		1	5		2.26	"
10	9	13	35	21	3	12	6		1		1	5		2.33	"
11	9	13	34	21	4	10	5		1		1	4		2.38	"
12	10	16	35	21	1	12	9		1		1	8		2 45	"
13	10	15	36	21	2	12	8		1		1	7		2.50	"
14	10	13	36	21	0	11	6		1		1	5		2.54	"
15	10	16	35	21	0	13	8		1		1	7		2.58	"
16	10	15	36	21	0	12	9		1		1	8		3.03	"
17	9	13	35	21	0	12	6		1		1	5		3.07	"
18	10	15	35	21	3	13	8		1		1	7		3.11	"
19	9	13	34	21	2	12	8		1		1	7		3.15	"
20	10	15	35	21	6	12	6		1		1	5		3.20	"
21	10	15	35	21	1	13	7		1		1	6		3.25	"
					Row	No.	22								
21	10	15	34	21	0	12	7		1		1	6		3 33	"
20	10	15	34	21	0	13	10		1		1	9		3.55	"
19	10	15	35	21	4	12	7		1		1	6		4 03	"
18	9	13	35	21	1	13	7		1		1	6		4 09	"
17	9	14	35	21	1	12	8	1			4	4		4.15	"
					Row	No.	32.							A.M.	Mar.
3	9	14	34	18	0	13	5		1		1	4		7.39	30
4	9	13	40	18	0	14	5		1		1	4		7.54	"
5	9	16	37	18	1	14	5		1		1	4		8.00	"
6	10	16	35	18	1	13	6		1		1	5		8.14	"
7	10	16	35	18	0	15	6		1		1	5		8 35	"
8	8	12	30	18	12	13	3		1		1	2		8.44	"
9	9	12	30	18	20	12	3		1		1	2		9.00	"
10	10	16	38	18	0	14	5		1		1	4		9.06	"
11	10	14	36	18	0	15	5		1		1	4		9.17	"
12	9	13	38	17½	2	14	4		1		1	3		9.27	"
13	10	15	39	17½	1	14	6		1		1	5		9.42	"
14	11	17	36	18½	1	14	15		1		1	14		9.53	"
15	10	15	35	17½	0	16	5		1		1	4		10 05	"
16	10	14	38	17½	0	15	6		1		1	5		10.16	"
17	9	14	36	17½	1	14	5		1		1	4		10.23	"
18	9	15	36	17½	1	15	6		1		1	5		10.33	"
" Mooring Pile."	9	16	38½	17½	0	15	8		1		1	7		10 46	"
19	9	16	35	17½	1	14	7		1		1	6		10.55	"
20	11	16	40	17½	0	15	11		1		1	10		11.08	"
21	10	16	35	17½	0	14	7		1		1	6		11.16	"

TABLE I.—Continued.

Number of Pile.	Diameter. Inches. Bottom.	Top.	Length of Pile. Ft.	Depth driven. Ft.	Distance last blow. In.	Rebound of Ram. Ft.	Number of Blows.	Weight of Cartridge. Final. Ounces. 1	1½	1½	Number of Cartridges used. Ounces. 1	1½	1½	Time H. M.	Date.
					Row	No.	33.								1872.
														A.M.	Mar.
21	10	16	37	17½	0	15	7		1		1	6		11.30	30
														P.M.	
20	12	18	37	17½	0	14	11		1		1	10		12.13	"
19	9	13	35	17½	0	15	4		1		1	3		1.10	"
18	9	14	35	17½	3	14	6		1		1	5		1.34	"
17	9	14	35	17	0	14	5		1		1	4		1.40	"
16	9	14	35	17	0	13	5		1		1	4		1.43	"
15	9	14	34	17	1	13	5		1		1	4		2 00	"
14	9	14	35	17	0	13	5		1		1	4		2.04	"
13	9	13	35	17	4	12	4		1		1	3		2.13	"
12	9	14	34	17	1	13	5		1		1	4		2.20	"
11	10	15	35	17	3	14	8		1		1	7		2 30	"
10	9	14	35	17	4	13	4		1		1	3		2 38	"
9	9	13½	34	17	2	13	4		1		1	3		2.43	"
8	9	13	40	17	1	14	4		1		1	3		2.50	"
7	9	13	32	17	4	13	4		1		1	3		2.56	"
6	10	14	34	17	0	14	6		1		1	5		3 08	"
5	9	14	35	17	1	13	4		1		1	3		3.13	"
4	10	14	35	17	4	12	5		1		1	4		3.18	"
3	10	15	35	17	0	14	6		1		1	5		3.22	"
2	10	14	31½	17	0	14	10		1		1	9		3.30	"
1	9	15	35	17	0	15	10		1		1	9		3.40	"
					Row	No.	34.								
1	9	15	36	17	0	16	9		1		1	8		4.15	"
2	9	15	36	17	0	16	6			1	1		5	4.35	"
3	9	14	36	17	0	17	4			1	1		3	4.43	"
4	9	13	32	17	20	15	3			1	1		2	4.52	"
5	9	14	40	16½	0	17	4			1	1		3	5.12	"
6	10	15	36	16½	0	14	5			1	1		4	5.19	"
7	9	14	36	16½	0	15	5			1	1		4	5.24	"
8	9	14	36	16½	0	14	4			1	1		3	5.29	"
9	9	14	35	16½	0	15	5			1	1		4	5.33	"

TABLE II.

No. of Pile.	Diameter Inches. Bottom.	Top	Length. Ft.	Height of fall Ram. Ft.	Depth driven by Impact. In.	Depth drivennext blow by Explosion. Inches.	Weight of Cartridge. Oz.	Height of rebound of Ram. Feet.	Remarks.
					Experimental.				
235	8	13	35	15	6	30	1	9	2d and 3d blows upon pile.
236	8	12	35	15	3	12	1	9	3d " 4th " " "
237	8	13½	35	18	1	8	1	9	5th " 6th " " "
552	9	12½	35	20	2½	12	1¼	15	Pile 12 ft. below surface. 5th & 6th blows upon pile. Block crushed to pieces.

The impact was obtained by letting ram fall upon heavy oak block placed over mouth of gun. The rebound of ram after explosion was generally somewhat retarded by a too early application of the piston brake.

already in motion when a tremendous force is suddenly brought to bear upon it in the same direction, and in the other case it receives a violent blow when at rest and a considerable portion of the force is expended uselessly in the destruction of the pile-head itself before its inertia is overcome and motion produced. Hence the necessity of strongly banding the pile-heads in the latter case, and the utter absence of any necessity for their protection in the former.

The ram on its rebound is caught and held by the brake, and the operation repeated at pleasure.

The following record of each pile driven was kept, viz.: Diameter at top, diameter at bottom, length, depth driven, distance driven at last blow, height of rebound of ram, number of blows, number and weight of cartridges used, do. of last cartridge, and the time.

I have not yet had time to carefully summarize the whole record, but will furnish you with a complete copy, if you desire it. I enclose you, however, a copy of the record for January 13th, when 12 piles were driven in a single hour, under favorable circumstances; also for March 30th, when 50 were driven in a single day.*

Some of the smaller piles were driven to hard bottom with 3 blows, but generally required from 5 to 8 blows, according to size; and in some instances as many as 15 blows were necessary to penetrate the hard bottom. The piles were all driven without the slightest injury, and none of them showed any marks of violence.

The work began Nov. 9th last, and continued, with several interruptions, unil Dec. 4th, when it was suspended for the winter. It was again commenced Jan. 12th, but after a few hours' work on the 12th and 13th it was again suspended, on account of the cold weather, until March 15th, when the work was resumed, and completed April 4th.

The total working time, as per record, foots up 187 hours, making an average of only 4·3 piles driven per hour. Considerable loss of time was occasioned, however, in waiting for piles, and by sundry vexatious delays incident to the operation of a new machine with inexperienced workmen, and the shoal water also caused considerable interruption by the grounding of the scow.

In fact, the conditions of weather, shoal water, supply of piles, &c., unfortunately proved unfavorable for a full exhibition of its

*The complete record has been requested, and will be published in a succeeding number.—Ed.

power when working up to its capacity for several days in succession without interruption, and I am therefore disappointed in being unable to obtain such a record.

Average depth actually driven, 19·4 feet; average number of "blows" per pile, 5·2; average weight of powder per pile, 8·2 ounces.

The largest number driven in any one hour was 12, as before stated, and 50 in any one day.

To demonstrate the efficiency of this method as compared with the ordinary method of driving piles, I caused several experiments to be made by letting the ram fall upon a heavy oak block placed over the muzzle of the gun to receive its blow, like an ordinary hammer, noting the effect, and then following it with explosion of a cartridge, and noting its effect. The result was in favor of the new method in the ratio of from 4 to 1, to 8 to 1, as shown by the enclosed record of the experiments.

There is no doubt of the entire practicability of this novel method of driving piles, as well as of its great superiority. Greater penetration can be secured and with much greater ease than in the ordinary process; no banding or protection whatever is required for the pile-heads; no loss of any portion of the pile from injury, and the pile is infallibly guided home without assistance, saving time and avoiding all risk of accident in this respect, while the rapidity of its action coupled with the enormous pressure of its "blows," and without the slightest injury to the pile, I believe to be unequalled by any process.

Some defects of construction in this machine have been developed by this trial, and which have operated to prevent its entirely successful operation, but which can be easily remedied in another.

Government Aid to Science.—We learn that a number of scientific gentlemen connected with the Smithsonian Institution and the Naval Observatory have united in a memorial to Congress, urging upon it the appropriation of a liberal sum ($150,000) to be devoted to thoroughly organizing expeditions for the observation of the approaching transit of Venus. The number and importance of the astronomical questions which it is hoped this event will enable astronomers to definitively settle, cause it to be awaited as a celestial phenomenon more eventful than any that have occurred for many years. There is every reason to hope that the same intelligent interest and support which has thus far been manifested by our government in scientific work, and which have won for us the admiring comments of the scientific fraternity abroad, will enable our expeditions to go forth fully equipped and able to compete with those of other lands.

Chemistry, Physics, Technology, etc.

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

(Continued from page 356.)

Chimenti Pictures.

Subsequently to the publication of his book,* from which the preceding quotations have been made, Sir David Brewster introduced the so-called Chimenti Pictures into the controversy. It happened that Dr. Crum Brown, of London, about 1869, during a visit to Lille, noticed two plane line drawings, apparently perfect fac similes, hung side by side in the same frame.

Fig 10.

The subject, as given in fig. 10, which is a copy of the right hand picture, is a man sitting on a stool, having a pair of compasses in one hand and a string in the other; their size about 12½ inches high by 8½ inches wide; their reported author the artist Chimenti. He thought that, by convergence of the optic axes upon them, he obtained stereoscopic relief by their combination, and reported the fact to Sir David Brewster. It was only after personal application of Prince Albert to the Emperor Napoleon that permission was granted to photograph these pictures. They were soon thereafter placed before the public in the form of an ordinary stereograph, with a descriptive label, embodying the opinion of Sir David, that the pictures constituted a true stereograph, and that it was the intention of the artist that they should do so. They became at once the subject of animated discussion; some experts with the stereoscope attributing true stereoscopic effect to them, and others as decidedly denying it.

* "The Stereoscope," London, 1856.

Casting out of the controversy these apparently conflicting opinions, founded simply on inspection by means of the stereoscope, careful measurement and comparison of the distances between identical points of the foreground with those between identical points of the background, showed that there should indeed be a mixed stereoscopic and pseudoscopic effect; for the variation in these distances did not follow the rule given in the preceding pages for the production of stereographs, since they did not increase, for all points, in passing from points in the foreground to those in the background. Thus, whilst some points, intended to appear in front, were nearer together than others, intended to appear more remote; on the other hand, some points, which it was just as evident were intended to appear in the foreground, were further apart than others as clearly in the background. Thus, a portion of the dress overhanging the left knee seems, in the stereoscope, to try to recede behind the knee, and on measurement, the distance between corresponding points of the folds of the dress is found to be *greater* than that between corresponding points of the knee. So the distances between corresponding points in the line of the back, in the two pictures, from the girdle to the lapel on the left shoulder, are less than the distance between the tops of the left knees, giving that line a tendency, when the pictures are viewed in the stereoscope, to take a position in front of the knees—evidently a pseudoscopic effect. A complete analysis made of the pictures in this way, by careful measurement, one of the most exhaustive having been made by Professor Emerson, shows that it matters little indeed which of the two pictures he assumed as the right-eye picture, except that, by one arrangement of them, there may be a preponderance of stereoscopic over pseudoscopic effect, which, with the other criteria of the picture, might, in a casual or inexperienced observer, create the impresssion of true stereoscopic effect of the whole, and easily account for the conflicting opinions, rendered in the earlier stages of the controversy, after simple inspection in the stereoscope. Some, as would be most natural, seem to have been influenced most by the points that were truly stereoscopic, whilst others, observing more closely, and perhaps with less bias, saw decided symptoms of unnatural, pseudoscopic effect. It is plain that careful measurement, as before given, alone was competent to decide the question as to the purpose of these pictures, and since it revealed such conflicting stereoscopic data throughout, it remained hardly supposable that any artist of reputation could have designed them as companion binocular pictures, much less that

he could have designed them to be united in some way or other to produce an impression of relief. Besides, the pictures, on careful measurement, did not prove to be identical in size, one being about one-half inch larger than the other.

It seems, therefore, that one is most probably a copy of the other; that the differences are purely accidental, and such as are unavoidable in copying, and that, therefore, when compared, the difference in distances of corresponding points is sometimes on the side of stereoscopic effect, and at other times on the side of pseudoscopic effect. Thus, any copy of a drawing, however carefully executed, and of course of the same size, will form with the original a stereograph, similar in effect to the Chimenti Pictures, to a greater or less degree of mixed effect. It has indeed been proposed, among the numerous applications of the stereoscope, to employ it for the detection of counterfeit bank notes, by comparing a suspected one, in the stereoscope, with a genuine one as a complementary picture, in which case the minutest differences in engraving would cause some parts, or letters, &c., to appear in front of, or behind, the plane of the paper. It would, of course, require considerable experience in the use of the stereoscope to render it available in such cases. The remaining arguments in favor of the stereoscopic character of these pictures, and consequent antiquity of the stereoscope, are summed up in the following remarks of Sir David Brewster: "The stereoscopic pictures have been preserved as the work of Chimenti himself, and the historian of science will naturally ask what led so eminent an artist to make so uninteresting a sketch as that of a man sitting on a stool, with a pair of compasses in one hand and a string in the other. He will ask what led him to make a copy of it of the very same size, and without any change or improvement whatever. He will ask what led him to preserve such uninteresting sketches. But, above all, he will ask, with a peculiar interest, what led him *to place these two figures side by side*, and in such manner that the instant they were seen by an intelligent traveller, Dr. Crum Brown, he conceived that they were intended to be brought into relief by binocular vision, and actually brought them into stereoscopic relief by retiring and combining the two separate pictures. The historian of science will not even be satisfied with the obvious answers to these questions. He will inquire into the *date* of these drawings, and he will be struck with the fact that they were executed at the time when Baptista Porta had called the attention of philosophers to the subject of binocular vision, and

had shown, in a diagram so far resembling a stereoscopic slide, that external objects—that is, objects in relief—were seen binocularly by the combination of a right- and left-eye picture of them. He will also connect with these facts, though he may not give it much weight, the statement of Prof. Archer, the distinguished director of the Industrial Museum of Scotland, 'that just before he left Liverpool, in a turn-out of the Museum there, *what appeared to be a stereoscope was found*, bearing the date of 1670.' 'Being out of order,' he adds, 'it was laid aside at the time, and probably had not been touched since.' 'It appeared,' he said, 'to be of *Roman* manufacture; and he suggested that an attempt should be made to get it for examination, as having an important bearing on the subject before the Society, namely, the subject of Chimenti's stereoscopic figures.' In forming his opinion from these various considerations, the historian of science will not fail to notice that the binocular theory of Baptista Porta was published in *Italy*, in 1593; that the stereoscopic drawings, which so wonderfully illustrate it, were also made in *Italy* some time after this, between 1620 and 1640; and that the probable stereoscope in Liverpool, with the date 1670, is considered to be of *Italian* origin."

Many of the arguments involved in the above have already been disposed of. That drawn from the assumption that the pictures are by Chimenti, by him arranged side by side, with some design, etc., loses much of its force, when the fact is considered that the pictures in the Museum at Lille were part of the plunder of Napoleon I; that these pictures are only *presumed* to be by Chimenti on account of their style, and that they were most likely placed side by side in the arrangement of the pictures in the gallery, because they were alike.

The account of the Liverpool stereoscope is almost Pickwickian, and only merits notice on account of Sir David's connection with it. Suffice to say that, upon more careful examination, it turned out to be a somewhat peculiar binocular telescope, with the date 1726 upon it.

Object of the Stereoscope.

The object of the stereoscopic instrument is frequently most conveniently stated, in a general way, to be the apparent superposition of the two dissimilar pictures of a stereograph, so as to enable any one to combine them readily, and receive from them a single resultant impression of a body in relief. For the sake of convenience such statements are allowable, but the part that any kind of stereoscopic instrument plays, will be much more fully comprehended by recalling

the difficulty involved in viewing such dissimilar pictures by the *unaided eyes* so as to obtain the impression of relief, and remembering, at the same time, that it is this difficulty that the instrument is intended to obviate. The eyes, in any of the methods for combining the pictures without the aid of an instrument, as stated in the discussion of these methods, must be accommodated for distinct vision to the plane of the paper on which the pictures are drawn, whilst the axes, contrary to unvarying habit, must be converged to a point more remote, according to one method, or to a nearer point, according to the other; and the dissociation of these invariably associated optical adjustments constitutes the great difficulty which the stereoscope, of whatever construction, is intended to remove, by so bending the rays of light emanating from the pictures, that they may seem to the eyes, properly placed, to be in the same place.

It will be sufficient to examine how this is accomplished in the two principal forms of the instrument, namely, the reflecting stereoscope, proposed by Professor Wheatstone, and having therefore an additional historic interest, and the refracting or lenticular stereoscope, devised by Sir David Brewster, which has come into such general use, and which, probably more than any other, is generally suggested by the word stereoscope.

Wheatstone's Reflecting Stereoscope.

Fig. 8.

Mirrors were employed in this instrument. Their arrangement and application belongs to elementary optics. Thus, fig. 8, AB and AB′ represent sections of two plane mirrors, placed at right angles to each other. A ray of light, emanating from an object at R′, a wafer, for example, on striking the mirror AB, would be reflected toward R, and, according to the laws of reflection of light, the object would appear, to an eye placed at R, to be located at C, in the direction of the reflected ray, on the line drawn perpendicular to the mirror from R′,

and as far behind the mirror on that line as R′ is in front of it. Movement of the object R′, along the line on which it is placed, it is evident, would change the position of C, the location of its virtual image. For the same reason, a wafer can be placed on L′ so that its image should appear to be at C, to an eye placed at L, after reflection from the mirror AB′. If complementary pictures are substituted for wafers, and R and L represent the right- and left-eye respectively, it is plain that these pictures would appear to be located at the same place, or be superposed; *the optic axes would be converged, and the eyes adjusted focally to points in the same plane*, the cause of the difficulty before alluded to will have been removed.

By inspection of fig. 9, the form and use of the instrument will more fully appear. On the vertical frames L′ and R′ are grooves, in which the left- and right-eye pictures are slid, as those of the frustum of the cone represented in the figure. The face is brought close up against the board, represented by the dotted line, placed along the line of junction of the two mirrors, AB, AB′, each of these being about four inches square. The eyes will then be in position to have their proper pictures presented to them. The pictures are then moved back and forth in the grooves until, apparently, complete superposition is effected, when the figure will immediately start out in relief. The pictures will coincide, more or less perfectly, in different positions, but the finest effect is only produced when they occupy similar positions relative to their respective mirrors. The upright frames, on which the pictures are slid, were also connected by a right- and left-handed screw, so that they could readily be made to approach or to recede from each other, thus permitting a variation of the distance of the pictures from the mirrors.

This form of stereoscope has some advantages over the next to be mentioned, especially in the fact that the size of the pictures to be employed is not as restricted, and that the same pictures may be employed pseudoscopically, since they are on separate cards, but it is plain that, on account of the lateral inversion in images formed by plane mirrors, which causes an officer, for example, to appear to hold his sword in his left hand, the pictures, in order to produce a proper effect, must be

drawn with this lateral inversion, or they must be transparent, so that they can be placed before the mirrors in either position. It is also apparent that the form of the instrument is not as compact, nor in any way as convenient, as that of the common lenticular stereoscope, and that, in viewing transparencies, it would require two lights of equal intensity, one behind each picture.

In explaining the action of the stereoscope, it is not necessary, however, to regard the simple apparent superposition of the pictures, as the cause of the appearance of relief, since this fact may be explained on the same theory as that adopted for the explanation of the perception of relief in the objects themselves, in the sections on *Binocular Vision*, and subsequently, namely, that of the movement of the optic axes in passing from the view of one point, in case of the real object, or of identical points, in case of pictures, to another point, or other identical points of the pictures, nearer or more remote. For the superposition of the pictures cannot, in the nature of the case, be perfect, on account of the dissimilarity of the pictures, so that, if they are adjusted so that identical points of the foreground in the pictures coincide, identical points in the background will necessarily not coincide, and the more remote the points represented the greater the want of coincidence. The eyes, however, take this up, and readily cause these points to coincide in turn, in running over the pictures, by slightly decreasing the convergence of the optic axes, by rolling the eyes outward,—a movement similar to that required in passing to objects in the background, in viewing the objects themselves, and consequently producing the same mental impression of increased distance or relief.

THE GREAT FIRES OF 1871 IN THE NORTHWEST.

By Prof. I. A. Lapham,
Asst. to Chief Signal Officer U. S. A.

1st Paper.

The great fires that have recently spread, with such disastrous results, over our whole northern frontier, from the Rocky Mountains to central New York and Pennsylvania, must be regarded as the effect of meteorological causes. Unusual dryness has pervaded the atmosphere during the past two months; the amount of rainfall has been very considerably less than the average and the amount of evapora-

tion considerably more.* Very little rain has fallen upon most of this extended region since August.

Winds from a south-westerly direction, blowing often with great force and for several days continuously, bring to the great prairie region of the West this excessive dryness. Their prevalence is often shown by the direction towards which the trees lean; they absorb moisture from every source, making everything of a combustible nature still more combustible. The soil itself becomes desiccated to a considerable depth. Pine lumber, of which houses, barns, fences, &c., are made, becomes excessively inflammable. The weeds and grass of the prairies and stacks of hay and grain are deprived of all moisture, and partake of the nature of tinder.

When these winds are blowing, a small spark is sufficient to kindle a great fire; the camp fire, the wad from a gun, a spark from a locomotive, even the remnant of a cigar, or the ashes from a pipe, may start a fire that will spread over a county. A stroke of lightning has, doubtless, been the origin of many a prairie fire. The Indians are said to have purposely set them on fire to rout the deer and other game.

The violent wind hastens to spread the flame over a constantly widening space, until large districts are laid waste by the "destroying element." It is familiarly known that these fires have annually spread over the great prairie region of the Mississippi Valley since their first exploration. Prairie fires are no new thing. Of course they vary in extent from year to year, according to the varying dryness of the seasons and other meteorological causes. A smoky atmosphere in autumn has been the common experience every year; and this smokiness has its origin in prairie fires at the West.

The fire once started in the dry grass and weeds of the prairie cannot be extinguished; it must take its own course, gradually widening as it moves forward, until it presents a front of a hundred miles or more; and the flames, often reaching a great height, are blown forward, setting fire to places many rods ahead.

These fires do not kill the roots of the prairie grass, which springs up fresh from the blackened soil, when its proper season returns; but the germs of other plants, including all forest trees, are destroyed.

When these fires reach the borders of the forest region the trees

* Rain at Milwaukee in September: Maximum (1841) 7·02 inches, mean of twenty-nine years 2·88—minimum (1871) 0·60.

are attacked, and many of them destroyed; others are more or less injured. The young shoots are killed; the roots beneath the soil, and in many cases even the soil itself is consumed.

It is when the south-west wind is high, and the atmosphere dry, and when, from long absence of rain, the vegetation is also dry, that we are to look for these great prairie fires.

We thus have before us the true theory of the origin of the prairies; they are clearly due to the dryness of the climate in autumn and the consequent fires. Their existence is not due to the effect of dryness of climate upon the growth of trees themselves, for, when protected from fires, trees are found to flourish in the prairie region. It is by fire (induced by dryness) that the trees are destroyed or prevented from growing.

These conditions of climate, the autumnal dryness and the prevalence of south-west winds, have existed for ages, and hence the normal condition of the great western plains is that of prairie; and so long as these causes exist, this region must always remain in this condition, unless changed by ingenious and persistently applied devices of art.

The normal condition of other regions is that of forest growth. When old fields are abandoned within these forest regions, as in Virginia, &c., or wherever lakes have been drained, a growth of trees immediately takes possession of the soil. In a few years the forests have resumed their possession.

Within the prairie region the soil is equally well adapted to the growth of trees, and, by continued effort in the prevention of fires, they may soon be made to cover the land with their grateful shade, their beauty and their usefulness; but should these efforts be discontinued for a few years, *the dry weather*, the *high winds* and the *accidental fires* will surely do their appointed work, and the prairie grass will resume its possession of the ground. The normal condition of prairie will again be established.

The northern boundary of the region of prairie forms a line which varies from year to year as the seasons vary. A continued succession of dry seasons encourages great fires, that penetrate the forest border and extend the area of the prairie; while a similar succession of wet seasons may allow a growth of trees to spread far within the proper boundaries of the prairie. A constant struggle is thus maintained between the two conditions of forest and prairie, alternating within certain limits, and changing the position of the dividing line. It is

here that we find the "openings," or scattered trees, chiefly of the burr-oak (*Quercus macrocarpa*), which give so much park-like beauty to the landscape.

The work of extending the prairie border was exhibited in the autumn of 1871 upon the grandest scale. Fires have swept more or less completely along the whole northern frontier, from the Rocky Mountains through Dakota, Minnesota, Wisconsin and Michigan, and even into New York and Pennsylvania.

Within the past two or three decades this region has been occupied and "improved;" farms have been opened; mills built, especially throughout the "lumber region" or places where the stately white pine (*Pinus strobus*) predominates. Villages, large towns, and even great cities have sprung up along this prairie border line with a rapidity truly wonderful. And now it is found that these natural, ever recurring meteorological causes which have for so many ages prevented the growth of forest trees, are equally operative in preventing the *building of houses, towns and cities.*

Not only has the wild prairie region been swept by the fires of 1871, but thousands of square miles of forests have been destroyed. Many farms, with their houses, barns, stacks of hay and grain, miles of fences, &c., have been destroyed. At the same time a number of towns and a large part of the city of Chicago were consumed, involving the loss of many thousand human lives. The ground upon which these improvements were made has been reduced to the normal condition of prairie.

It becomes apparent then, that if we wish to occupy and improve this prairie region, to cover it with villages, towns and cities, to cultivate its rich and productive soil, we must contend against this natural law, which constantly and surely tends to assert its power to reduce everything to its former normal condition. To do this will require more than individual effort—only united and enforced, or in other words governmental effort can afford hope of success.

The precautions necessary to resist this destruction of property are of the simplest kind, being only such as are necessary to prevent the occurrence and spread of fire. This involves not only watchfulness, but the disuse, as far as possible, of all combustible materials. The watchfulness should extend not only to our own premises, but to prevent the carelessness and criminality of others; which can only be done by public authority. The use of kerosene in all its forms should be prohibited; no locomotive should be allowed to move without ade

quate means to prevent the emission of sparks from the smoke stack, and no fences of wood should be built. If the farmers of France, Germany, &c., can do without fences, certainly we can do the same, and thus save not only this food for the fires, but one-half of the aggregate capital required in the conduct of our agriculture! A thousand other measures, needless here to mention, should be adopted and *enforced*, looking to the same end.

It is announced that some farmers who have "lost their all" by these fires have become disheartened and discouraged, and will entirely abandon their possessions. If this is done now, while everything is fresh and new, while the soil retains its virgin richness, what may we expect in after years? Gradually, but surely, the whole country will be reduced (as have been the once fertile plains of the East) to the condition of a desert. It is true this may be in the distant future, but it is nevertheless our duty to prevent this result, so far as it is within our power.

If fences could be dispensed with, and if our houses could be constructed of materials other than wood, the very great destruction of our forests, now going on with such fearful rapidity, would be checked. It is estimated that fifty years will suffice to consume the pine lumber of Wisconsin and Michigan, the chief present sources of supply; the time therefore is close at hand when the forests will no longer supply the lumber used in temporary construction, erected only to increase the danger of great public calamities by fire!

Should the present policy be continued, the destruction of a large share of the newly built railroad stations in the prairie region of the West will surely come; they are built in opposition to the law of the land, a law that sooner or later must be enforced. A dry season, a strong wind and an accidental fire, whenever they occur together, will do the work.

If these views be correct, it is apparent that the precautions against these greater calamities are most needed at the south-west part of the town or city; here is always the place of greatest safety, and here should be erected buildings for the preservation of the most precious records and works of art, which, if lost, cannot be restored. Had the fire of Chicago originated at the north or east side of the city, the barn in which the kerosene lamp was kicked over alone would have been burned.

Milwaukee, Wis., Oct. 26, 1871.

SPECTROSCOPIC NOTES.

By John H. Leach.

(Communicated by Professor C. A. Young.)

Although Fr. Secchi and others have recently published descriptions of the different varieties of solar prominences which have been observed, well illustrating the many forms in which these outbursts from the sun's chromosphere occur, a careful record of such disturbances as may be out of the more common order may in the end assist us to a farther knowledge on this subject.

While looking for bright lines near F in the spectrum of a low prominence situated 25° north of east, at 11.35 A.M. (April 2d), my attention was called to what appeared to me a sudden displacement of the F line toward the violet end of the spectrum.

I immediately brought the C line into the field of view, in order to discover if any change was taking place in the form of the prominence, but was wholly unprepared for the spectacle which met my eye. Upon widening the slit I found that where only twenty minutes before there had been a comparatively low mass of prominence matter, not exceeding 50″ in height, and remarkable only for the brightness of a jet issuing from the southern portion which was but slightly raised above the chromosphere, there had been an eruption of matter on a grand scale.

Fig. 1 represents the prominence as first seen at 11.15 A. M.. At 11.35 A.M. the northern portion had entirely disappeared, and from the low mound, at the point where the jet mentioned above had been seen, an eruption had taken place far exceeding anything I have ever witnessed. Far above the chromosphere the air was filled with long wisps of glowing hydrogen, ranging from 20″ to 50″ (seconds) in length, with the appearance of having been ejected in quick succession. Above them floated detached masses, in the form of thin fleecy clouds, and the highest point reached by these was fully five minutes of arc, or about 135,000 miles above the sun. In the mound appeared a low, sharp horn, exceeding in brightness any other portion of the prominence. The grandeur of the eruption lasted but a few minutes, gradually fading in brightness and diminishing in size.

Fig. 2 gives a correct idea of the general form and extent of the prominence as seen at 12 M.

When next observed, at 1.40 P.M., nothing was left but a small

Fig 1
S
11.15 A.M. April 2 1872

Fig 4
2 P.M. April 2 1872

Fig 2
S
S
12 M. April 2 1872

Fig 3
2 20 P.M. April 2 1872

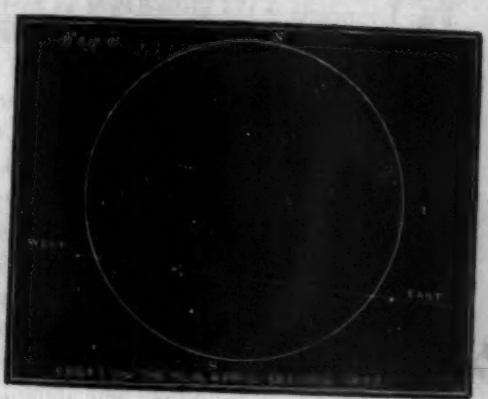
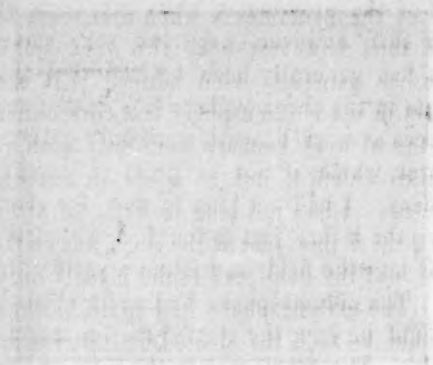
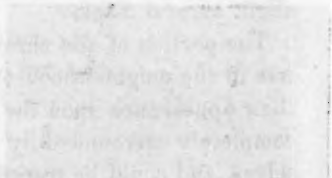


Fig 5
S
WEST
EAST

Fig 3
N
S
1.40 P.M. April 2 1872





cloud mass of about the height of the prominence when first seen, at 11.15 A.M. To the north of this, however, were two very small horns, of great brightness. It has generally been noticed that the appearance of these bright points in the chromosphere is a forerunner of increased activity. The forces at work beneath were only gathering strength for a final outburst, which, if not so great in extent, proved to be equally magnificent. I had not long to wait, for after a few minutes spent in examining the F line, just as the clock was striking the hour I again brought C into the field, and found myself only in season for the grand finale. The chromosphere had again belched forth, and far above the sun could be seen the ejected matter, reaching to the height of 94,500 miles. The débris was in the form of jets or wisps, which appeared to be falling toward the chromosphere, here and there fretted with sharp horns or bristles. The remains of the first eruption existed unchanged since last seen, at 1.40 P.M., but the changes in the form of the new one were rapid; at one point the filaments were so interlaced as to resemble close network. In the more elevated portions the jets soon lost their brilliancy, and in less than an hour scarcely anything remained but a few stray wisps floating low down near the chromosphere.

Fig. 5 exhibits the change which the last outburst had undergone at 2.20 P.M.

During the phenomena the C and F lines were completely broken up, being displaced toward both the red and violet ends of the spectrum, the greatest displacement being toward the violet, in the F line extending to the iron line above F numbered 2082 in Kirchoff's map. The D_3 line also suffered a sensible displacement. I examined the magnetic needle during the outbursts and an hour afterwards, but could detect no unusual disturbance. In the evening there was a slight auroral display.

The portion of the chromosphere in which the eruptions took place was in the neighborhood of a group of spots which were just making their appearance upon the eastern limb of the sun. The spots were completely surrounded by faculæ which radiated from the spots themselves, and could be traced to the sun's edge. Fig. 6 shows the position of the spots upon the sun at the time of the eruptions. The sketches were made at the time of observation, and are as correct as the duration of the phenomena would allow, the general form and most of the details being preserved.

ON HALLEY'S COMET.

By Prof. Daniel Kirkwood.*

The distinguished astronomer, Mr. Hind, has traced back the returns of Halley's comet to the year 11 B.C. He remarks, however, that previous to that epoch, "the Chinese descriptions of comets are too vague to aid us in tracing any more ancient appearances," and that "European writers of these remote times render us no assistance." It is now proposed to inquire whether the comet had probably made any former approach to the sun in an orbit nearly identical with the present.

It is well known that the modern period is considerably less than the ancient. Thus, the mean period since A.D. 1456—the first return recognized by Halley—has been 75·88 years; while from 11 B.C. to 1456 A.D. it was 77·27 years. In determining the approximate dates of former returns, the ancient period should evidently be employed. Now, it is a remarkable fact that of more than seventy comets,† or objects supposed to be comets, whose appearance was recorded during the six centuries immediately preceding the year 11 B.C., but one—that of 166 B.C.—was observed at a date corresponding nearly to that of a former return of Halley's comet. Of this object it is merely recorded that "a torch was seen in the heavens." Whether this was a comet or some other phenomenon, it is impcssible to determine. But the comet of Halley was more brilliant in ancient than in modern times. It seems, therefore, extremely improbable that seven consecutive returns of so conspicuous an object should have been unrecorded, especially as twelve comets per century‡ were observed during the same period. It would seem, therefore, that the perihelion passage of the year 11 B. C. was the first ever made by the comet, or at least the first in an orbit nearly the same as the present.

In a paper read before the American Philosophical Society, November 19th, 1869, it was shown that the aphelion distances of the comets of short period are nearly equal to the distances of the major planets Jupiter, Saturn, Uranus and Neptune; and that most of the comets now moving in elliptic orbits probably owe their periodicity to the

* Read (by title) at the Indianapolis Meeting of the American Association, August, 1871.

† See the Catalogues of Chambers and Williams.

‡ The average number.

disturbing action of these planets. The aphelion of Halley's comet, it must be confessed, is so remote from the plane of the ecliptic that Neptune's disturbing influence would be but feeble. Possibly, however, the *original* position of the orbit may have been considerably changed. It is an interesting question whether the difference between the ancient and the modern elements of the comet are chiefly due to the defective data, or to real changes produced by the planets. Burckhardt's elements for 989 A.D. make the longitude of the ascending node precisely coincident with that of the aphelion; while the present difference is about 69 degrees. If it be granted that the transformation of the orbit was produced by Neptune, at what epoch could the change have been effected? In other words, at what time before the Christian era was the comet in the vicinity of its aphelion when Neptune had nearly the same longitude? It is certainly remarkable that for a thousand years preceding the passage of 11 B.C., there was but one such epoch of maximum disturbance, and that this occurred about 50 B.C.

A NEW LANTERN-GALVANOMETER.

By Alfred M. Mayer, Ph. D.,

Professor of Physics in the Stevens Institute of Technology, Hoboken, N. J.

On the 21st of December, 1871, I delivered a lecture on "The Earth a Great Magnet"* before the American Institute, at the Academy of Music, in the city of New York. In the experimental discussion I then made of the earth's magnetism, it was necessary to use a galvanometer so constructed that the deflections of its needle would be visible to a large audience. At the same time, the astatic condition of this needle had to be so controlled that it could be readily altered during the progress of the lecture, and an arrangement of damping magnets had to be devised that would permit me instantly to bring the needle into the magnetic meridian, when disturbed therefrom whenever I set in action the large electro-magnet used on that occasion. Indeed one of the principal uses to which this galvanometer was applied in the lecture was the exploration of the magnetic condition of the space surrounding this electro-magnet. This I accomplished by rotating wire coils at various distances and positions around the magnet and leading the induced magneto-electric currents through the galvanometer.

* In course of publication by Charles C. Chatfield & Co., New Haven.

The lantern-galvanometer, which I will now proceed to describe, was devised on the 13th of last November, and as it has accomplished all that I desired I think that its service in the lecture room warrants this formal description of it.

Referring to the figure, M is a plane mirror, inclined 45° to the vertical. In front of this and quite close to it are the back condensing lenses of an oxyhydrogen lantern. The front lens of the condenser is placed *above* the mirror at G. The back condensing lenses are of such curvatures that when the calcium light is placed about two inches from the one nearest it, a beam of light of nearly parallel rays issues from them to fall upon M; thence to be reflected to the upper condensing lens at G. This arrangement of lenses is due to President Morton, of the Stevens Institute of Technology, and gives a bright and uniformly illuminated field, free from color.* Resting on G is a

* "The original idea and general plan of the instrument ['the vertical-lantern'] shown was, as the speaker (Prof. Morton) stated, due to Professor J. P. Cooke, of Cambridge, his own work in connection with it being confined to the devising of a convenient mechanical arrangement of parts, the improvement of the combination of condensing lenses with the reflecting mirror so as to secure a white and evenly illuminated field on the screen, and the discovery that an ordinary silvered mirror would serve for the final reflection as efficiently as a metal speculum or glass silvered by Foucault's plan, which are so difficult to obtain or keep in order."—*Quarterly Journal of Science*, October, 1871.

disc of glass, on whose border is photographed a divided circle. In the centre of this glass disc is a low needle point on which freely rotates a magnetic needle. Above the needle is the projecting lens L, the pencils from which are reflected in any desired direction by means of the plane mirror R, which rotates on a horizontal axis and has also a motion in azimuth around the axis of the lens. The horizontal condensing lens C has a diameter of five inches and the magnetic needle is four inches long.

To deflect this needle by an electric current I place as close to the condenser as possible the two spirals S and S′ formed of $\frac{1}{16}$ inch wire of *square section*, so as to bring the convolutions as close as possible. The turns of the spirals are separated by very thin vulcanite ribbon coated with paraffine; the spirals are wrapped on vulcanite discs and have an internal diameter of four inches and an external diameter of ten inches, and each contains about 49 feet of wire. The spirals are so placed on the sides of the condenser that a line joining their centres passes through the centre of the magnetic needle.

The vertical-lantern rests upon a base-board, 3 feet 6 inches long, with guides on its sides, between which slide boards carrying the two bar magnets A and B, each 15 inches long and 1 inch in diameter of section. These magnets cannot only approach to and recede from the lantern, and thus vary their distances from the galvanometer needle, but they can also rotate around their centres on vertical axes. Thus, the poles of the base-magnets being similarly placed with those of the galvanometer needle they render it more or less astatic as they are nearer to or further away from it. Also, in case the needle should not come to the meridian on moving the base-magnets, it can be made to do so by rotating about a vertical axis one or both magnets; and thus, also, can be neutralized any exterior disturbances tending to deflect the needle from the magnetic meridian.

The galvanometer-needle may also be rendered astatic by suspending it from above by a silk fibre and attaching to the needle a wire which descends through a hole in the condenser and in the inclined mirror and carries beneath the latter another magnetic needle with its poles reversed. In this arrangement we move the base-magnets to a greater distance and render the combination astatic by their action on the lower needle.

In working with thermal currents a smaller needle and condenser, allowing the coils to approach each other, can be used; but for the detection and measurement of currents of thermo-electricity it is

better to coil close around the upper needle a wire in a flat coil of only one wire in breadth. Thus the thickness of the surrounding coil need not exceed the breadth of the needle, and its image on the screen will form a single zero point.

I will now give a few experiments serving to show the usefulness of this instrument.

Experiment 1. A coil of 2½ feet in diameter, containing 40 turns of 300 feet of $\frac{1}{10}$ inch copper wire, was placed with its plane at right angles to the line of "the dip." The terminals were connected with the galvanometer, whose needle was rendered nearly astatic by means of the two damping magnets. I now rotated the coil quickly through 180° around an axis at right angles to the line of the dip. The needle was deflected about 12°.

Exp. 2. The two cores of the large electro-magnet of the Stevens Institute of Technology were placed end to end, thus making one iron bar of 7 feet in length and of 6 inches in diameter. This was surrounded with its 8 bobbins, containing in all 2000 feet of $\frac{1}{8}$ inch copper wire. Through this was sent the electricity developed by the the most advantageous combination of 60 plates of zinc and carbon, 8 × 10 inches.

A coil of 20 inches in diameter of one turn of $\frac{1}{8}$ inch wire was rotated around a vertical axis, 3½ feet distant from one pole of the core; the galvanometer needle moved over 3°.

Exp. 3. Same as exp. 2, *except* there were 5 turns of $\frac{1}{10}$ inch wire in the coil of 20 ins. diam. Deflection = 30°.

Exp. 4. A coil of 20 inches in diameter, formed of 20 turns of $\frac{1}{10}$ inch wire, was rotated through 180° around a vertical axis, 6½ feet distant from the pole of the magnet. Deflection = 22°.

Exp. 5. Same as exp. 4, but rotated coil with its centre 3 feet 8 inches above the equator of the magnet. Deflection = 80°.

Exp. 6. A coil of 2½ feet in diameter of 40 turns of 300 feet of $\frac{1}{10}$ inch wire was rotated with its centre 28 feet distant from equator of magnet. Deflection = 20°.

Exp. 7. The following experiments will show the excellent proportions of the coil used in Exp. 6 for the evolution and study of induced terrestrial magneto-electric currents:

I placed this coil on a table and connected its terminals with a galvanometer, such as is used in studying thermo-electric currents. The needles of this galvanometer made one vibration in nine seconds. On lifting the E side of this coil 6 inches, the galvanometer needle

was deflected 10°. Lifting the same side 9 inches the needle went to 22°. Placing the coil in a vertical N. and S. plane and suddenly tilting its top 6 inches to the E. or towards the W., the needles were deflected 60°. Tilting the top 9 inches sent the needles with a blow against the stops at 90°.

THE UTILIZATION OF THE LIGHT PETROLEUM OILS.

By William H. Wahl.

(A Paper read before the Optical Section of the Franklin Institute, March 28th, 1872.)

Amongst the problems which have taxed the ingenuity of practical minds for years, that of increasing the source and supply of illuminating agents ranks with the most important. The necessity for their increasing excellence and cheapness grows more urgent as our civilization advances, and it is scarcely to be doubted that the resources of science will prove equal to the demands to which she has given origin. The history, indeed, of the last half century furnishes an instructive illustration of the assertion, and will afford the future chronicler of human events a theme of unequalled richness; for his will be the record of a time in which such prodigious strides were made in every department of human knowledge, that it will stand alone an epoch-making period in the material progress of our race.

Not the least interesting of the items which go to make up the sum of our century's progress, is the development of the modes and appliances for procuring artificial illumination.

When the needs of increased culture first made an illuminating agent necessary, the torch, doubtless, furnished the material. Then followed probably the torch steeped in resinous substances; and the simple lamps, from which the heavy animal and vegetable oils were burned; then the candle was introduced. Then, in quite recent times, came the introduction of burning gas from coal; and finally, though it had doubtless been used in isolated localities for centuries before, came the general introduction of petroleum and its products.

In our own time, the needs of commerce have called for illumination of great intensity, which science has furnished in the oxycalcium, the magnesium and the electric lights. These have, however, for obvious reasons, but limited application, and as their general introduction for the purposes of the household is out of the question, they

only concern the purpose of this sketch as items in the history of the subject of illuminating agents.

Quite recently, indeed within the past few years, attempts have been made to increase the efficiency of the ordinary illuminating gas, by passing it through a well of some volatile liquid hydro-carbon; the process being termed super-carburetting. This plan has been slightly varied by mixing with the gases, before combustion, a quantity of oxygen; while the latest innovations comprise attempts, made with varying degrees of success, to utilize directly the lighter oils obtained in the rectification of petroleum.

It may not be generally known that the introduction of coal-gas was attended with unusual difficulties. The most vehement protests were proclaimed and circulated denouncing its introduction. It was characterized as eminently dangerous, impractical and injurious to health. It was only when time had demonstrated the groundlessness of some of the objections urged against it, and the gross exaggeration of others, and after the ingenuity of invention had shown how the dangers attending its use could be met and averted with ordinary prudence, that objectors were silenced, and the new light grew rapidly into popular favor. It is sincerely to be hoped that it will not prove otherwise with the light products of petroleum. The light which they emit is brilliant and beautiful, and, what is quite as important, the supply is practically inexhaustible; the demand for them in various technical operations is scarcely able to keep pace with the present supply—and should a new field for their utilization on a large scale be opened up, this supply could be greatly increased. With such possibilities, therefore, in our inventive era, the discovery of safe and economical devices by which these products of such valuable light-giving properties may be utilized for the purposes of illumination, for which nature has eminently fitted them, is manifestly but a question of time.

That the importance of the subject is duly appreciated by the practical mind of the country, is amply evidenced by the records of the Patent Office, by which it will be seen that the number of processes secured for devices suitable for the utilization of these light petroleum oils reaches several hundred. These may all, however, for the purpose of classification, be included under two underlying plans or systems.

In one of them, hydrogen gas is generated by some one of the methods suitable for the purpose, and this, by a suitable arrangement is made to pass through or about the light oils, the utilization of which

is to be effected. By this contact and the attendant mechanical agitation, the oil in each case is partially converted into vapor, which is carried along with the current of hydrogen in mechanical suspension. In this condition it is ignited, the illuminating property of the mixture being entirely dependent upon the oil vapor, since of itself hydrogen gas gives a non-luminous flame.

The second plan includes numerous mechanical devices by which a current of air, kept either at the common temperature, or heated by an external fire in order to facilitate the formation of vapor is drawn over or through a well of the oil. The air, like the hydrogen in the former plan, becomes surcharged with vapor, and in this condition is utilized.

Finally, the latest plan for illumination which has been published, consists in mixing ordinary burning gas with a certain proportion of air, and forcing the ignited mixture upon platinum sponge. The latter, by arresting and appropriating the luminous vibrations of the combining gases, becomes a brilliant point of light.

We have now before us, in some detail, all the processes of sufficient importance to warrant mention, which go to make up the history of the interesting subject of illumination. The peculiarities and the merits of these several plans will be our next consideration.

Burning Gas from Coal.—One of the most important discoveries which has been made in connection with the subject of artificial illumination, is the process of manufacturing and utilizing the gaseous products obtained in the distillization of bituminous coal. These utilizable illuminating products consist of the so-called light and heavy carburetted hydrogen—the same gases to which the candle and the torch owe their efficiency. The only difference in the comparison consists in the fact that, with the coal gas, we store up the combustible gases for future consumption, while with the candle or torch we produce these gases during the act of burning. The heat developed by the burning of one set of gaseous particles from the wood, is sufficient to generate in the woody fibre immediately adjacent, more of these gases; these, by their combustion repeat, the process, and this continues until all is consumed.

It cannot be doubted that the utilization of illuminating gas from coal is the most important discovery in technical chemistry with which the present century may be credited. Both directly and indirectly it has immensely benefitted mankind. A well-known writer sums up its advantages in terms nearly as follows:

"It has furnished us with a light so pure and steady, and of such cheapness, that those engaged in manufacturing pursuits may carry on their labor far into the night with little inconvenience and cost. It has drawn into more useful channels the brain and muscle of thousands formerly engaged in procuring from the soil or sea the oils then universally consumed in its stead. In a sanitary point of view it is far superior to its predecessors, both in point of cleanliness and in the absence of offensive smells from its combustion. Whether we view it from the commercial standpoint and estimate the increased wealth which has resulted from its introduction in every branch of trade and industry, or as a civilizing agent, which has added to the comfort, health and luxury of millions, the introduction of coal-gas ranks second to none of the discoveries of our times."

Petroleum.—On many portions of the earth's surface abundant springs of an oily fluid exist. These occur at times associated with indurate or semi-solid resinous matters called by various names, such as bitumen, mineral pitch, asphaltum, &c., which are now known to be the residuum left behind by the oils on their exposure to the air. These oils, whether occuring in Persia, on the shores of the Caspian Sea, or in our own country, all possess the same general properties, a fact which points strongly to the belief that they have originated under very similar conditions. The general horizon of the rocks from which the supply of the oil proceeds is in the neighborhood of the coal measures; but this is by no means universally the case, for it has been found in abundance in formations both older and more recent than those belonging to the coal-bearing series. But, whatever the nature of its occurrence, the peculiar character of the material leaves but little room to doubt the fact that it is a product of the slow decomposition, perhaps distillation of vegetable or animal matter or both. Though some differences of opinion may still exist in connection with the process of its origin, the organic nature of its formation has never been called into dispute.

The supply of this oil, especially in our own vicinity, seems to be practicably inexhaustible; but though this fact appears to have been known to some, no organized movement to utilize it appears to have been made, except locally, until within quite a recent period—less than twenty years.

When once its value as an illuminating agent became known, its introduction for the purposes of the household followed with great rapidity. In a few years an important and constantly increasing in-

dustry sprung up in the oil producing regions, which, offering unusually favorable opportunities for speculative enterprises, created a furore amongst men of every stamp, which received the happy sobriquet of the "oil fever." But despite the wide-spread commercial misfortunes which followed in the train of speculation, and which earned for many participators a questionable reputation for integrity, the value of the oil became more generally understood, and the demand for it increased to such an extent that to-day the growth of the industry engaged in its production is beyond comparison with any other.

This statement will, perhaps, be realized when it is declared that in the year 1870 there were, in the Pennsylvania region alone, more than 3000 productive wells, while the yield of the United States and Canada for the same year is estimated by careful statistics to have reached the enormous figure of 6,500,000 barrels.

As the chemical and physical properties of the oil petroleum may not be generally known, it is proposed to give, in as brief a space as possible, a description of them.

The crude oil, as it is sought from the wells, is of a variable color, but generally greenish or brownish in tint, possessing an unpleasant odor resembling that of bitumen. It is somewhat lighter than water, its specific gravity, though varying with locality, being about 0·85, water being taken as 1.

When heated, however, the curious fact is brought to light that, instead of being a simple homogeneous substance, the oil is composed of a great number of compounds very similar in their chemical character, but differing in their densities and in their boiling points.

In virtue of the last named property, the manufacturer is enabled, with the aid of well-regulated heat, to separate these numerous compounds from each other. The process here indicated is known as fractional distillation, and is always resorted to where it is desired to separate the ingredients of a mixture which have no destructive chemical action on each other, but which happen to have different boiling points. The mixture is placed in a suitable retort, connected with a cool condensing vessel, and a gradually increasing heat is applied until one of the components begins to distil over. The heat is then kept constant at this point until the distillation ceases. This is a proof that everything capable of boiling at that temperature has been removed and collected. The heat is then gradually elevated until signs of distillation are again observed; at this temperature it is re-

tained until the second distillate is collected; and so on until all the components have been separated.

Such is the general character of the process, then, which applied to the crude oils we have been describing enables the manufacturer to split them up into a number of useful substances; some of which, as being especially interesting, will shortly be described.

It is, however, necessary to add that the description above given is not absolutely correct, though in principle it is so, when applied to the processes adapted on the commercial scale for the rectification of petroleum.

The reason for this imperfect separation is that the crude oil is made up of so many, the boiling points of which lie very close to each other, that it is found in practice impossible to regulate the temperature of the crude material with sufficient nicety to separate the more accurately. So that each of the commercial products to which custom has attached a certain name, must not be understood to be a simple oil, but to be, perhaps, an intimate mixture of a number of them. The plan practice has determined to be the best for the purpose of describing which these commercial products is that of stating the extremes of the thermometric scale within which each has been collected. The statement of the density or specific gravity of the commercial products is met with oftener than that of the boiling point. This plan of designation must, however, not be looked upon as distinct from the one above stated, for it is simply a convenient mode, of which the manufacturer avails himself, of estimating nearly enough for practical purposes, the distilling temperature of a commercial oil. Seeing that the boiling point of each individual product stands in a well known rate to its density—the heavier the oil the higher its boiling point, and *vice versa*.

The advantage of this plan lies in its convenience. In commercial operations an attendant, from time to time, plunges the hydrometer into the distillate, until he perceives that it registers an oil of the desired weight. When this occurs the distillate is led into another collecting vessel, where a similar operation is conducted for a heavier oil than the first, and so on until all the operations are completed. By this process then the following products are obtained from the crude petroleum. The average gravity, for each of the products named, are those most generally accepted, there being, as far as our knowledge extends, no strict scientific division applicable to their definition:

Name.	Gravity.
Rhigoline, ...	
Gasoline, ...	85.
Naphthas, ...	65 to 70.
Burning Oils, ...	45.
Paraffin Oils, ...	Below 38.
Paraffin, Residuum, ...	Solid.

Of these products the first and the last three do not concern us directly, though a mention of their applications may not be uninteresting.

Rhigoline, which is the first product upon the list of oils, is an exceedingly light, limpid liquid, which evaporates quite rapidly when exposed to the air. It is used to some extent in surgical operations as a styptic, and constitutes generally about one per cent. of the crude material.

The heavy oils from which the solid paraffin is extracted are found very suitable, after chemical preparation, for the lubrication of certain parts of machinery, but beyond this they are of no interest. From the residuum the valuable color yielding products, in which the residues of the gas manufactories are so rich, have been obtained. With paraffin and its many important applications in the arts the intelligent reader is already familiar.

The burning oils are those which are now very generally used for household purposes in portable lamps. The naphthas, though largely used to adulterate the burning oils, is entirely unsuited and even dangerous, for reasons to be more fully stated hereafter, when used in the lamps constructed for the purpose of consuming the burning oils. Indeed a large proportion of the accidents arising from the use of petroleum is clearly attributable to this source of danger. Its proper utilization thus far has been confined mainly to a variety of processes in manufacturing. The few legitimate attempts, as yet announced, for applying this product for illuminating purposes have been those in which an apparatus specially designed for the purpose has been constructed. And there is little doubt but that, should it be found profitable to compete with this material against the illuminating agents which at present fully occupy the field, a number of plans could be devised by which it could be burned with any desirable amount of safety.

The gasoline, forming about 6—8 per cent. of the crude material, is

in appearance identical with the product just considered, and differs only in its gravity and its more ready volatility. It has many industrial applications similar to those of the naphthas, and is now, to some extent, used as an illuminating agent, the abundant supply of the material as well as the excellent light it affords having given origin to numerous plans for its combustion.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Meeting, Dec. 20, 1871.

The meeting came to order at the usual hour, the President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers and the reports of the several Committees. No donations were reported for the library.

The Committee appointed to examine and report upon the question of rating Steam Boilers, reported progress, and were continued.

The President appointed Messrs. Orr, Rollin, Hoskins, J. H. Cresson, Rand, Gardom and Mason as Judges of Election for the year 1872.

The following nominations for officers for the ensuing year were made:

President.—Coleman Sellers.
Vice-President.—B. H. Moore.
Secretary.—William H. Wahl.
Treasurer.—Frederick Fraley.

Managers to serve three years.—Washington Jones, Pliny E. Chase, Charles S. Close, J. M. Wilson, William P. Tatham, Dr. Isaac Norris, Jr., Robert Briggs, William P. Durfee.

To serve two years.—Edwin J. Houston.

For Auditor.—Samuel Mason.

The Secretary's Report upon Novelties in Science and the Mechanic Arts was read, upon which the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, Jan. 17, 1872.

The meeting was called to order by the President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the meeting held January 17th, 1872, the following donations had been made to the library:

From the Royal Astronomical Society, and Royal Geographical Society, of London, England, Smithsonian Institution, Washington, D. C.

The judges of election reported the following gentlemen elected as officers of the Institute for the year 1872:

President.—Coleman Sellers.

Vice-President.—B. H. Moore.

Secretary.—William H. Wahl.

Treasurer.—Frederick Fraley.

Managers to serve three years.—Washington Jones, Pliny E. Chase, Charles S. Close, J. M. Wilson, William P. Tatham, Dr. Isaac Norris, Jr., Robert Briggs, William P. Durfee.

To serve two years.—Edwin J. Houston.

For Auditor.—Samuel Mason.

The report of the Committee on memorial to the late Actuary, Mr. Hamilton, was read, and subscriptions reported.

The Secretary then read his report upon Science and the Mechanic Arts, when the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

New Method of Observing the Sun's Rotation.*—Zöllner and Vogel have succeeded in making measurements of the velocity of the sun's rotation with the spectroscope. The method pursued is too elaborate to be described in a brief notice. The value obtained for the motion of a point on the sun's equator is 0·42 German miles per second from one series of observations, and 0·35 miles from a second series. These values are somewhat greater than those at present received. As a new application of the spectroscope, optically demonstrating the fact of the sun's rotation, these experiments are of much interest.

* Pogg. Ann. cxliv, 449.

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